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This document contains the findings of a waste audit study of the pesticide formulating industry. The study found that the options of waste recycle, treatment, and source reduction are applicable to the pesticide formulating industry as a whole. The study also addresses the cost/economic benefits of implementing the waste reduction techniques. Finally, the report contains a self-audit format questionnaire and checklist so individual plants may assess their own waste management practices and waste reduction opportunities.

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WASTE AUDIT STUDY

PESTICIDE FORMULATING INDUSTRY

PREPARED FOR

ALTERNATIVE TECHNOLOGY SECTION
TOXIC SUBSTANCES CONTROL DIVISION
CALIFORNIA DEPARTMENT OF
HEALTH SERVICES

PREPARED BY

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

SACRAMENTO, CALIFORNIA

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ABSTRACT

The State of California Department of Health Services (DHS) is charged with the implementation of a hazardous waste reduction program in support of the state mandate to phase out land disposal of hazardous wastes. DHS contracted Environmental Science & Engineering, Inc. (ESE) to perform a waste audit study of the pesticide formulating industry. The objective was to evaluate waste management methods currently practiced by this industry. Recommendations for waste reduction were developed. Included is a self audit format which could be used by pesticide formulating plant personnel to conduct their own audits.

Waste audits of three pesticide formulating plants were conducted. Plant selection emphasized small businesses which generally lack the financial and/or internal technical resources to perform a waste reduction audit. However, one relatively large plant was selected for study. It offered the opportunity to evaluate a wide variety of pesticide formulating operations, as well as a number of in-place waste reduction measures.

The findings of the waste audit study were used to develop and recommend waste reduction opportunities. These are waste recycle, treatment, and source reduction options that are applicable to the pesticide formulating industry as a whole. The costs/economic benefits of implementing the waste reduction techniques were also addressed in this study. Finally, the study findings were also used in the development of the self audit format questionnaire and checklist. It is intended for use by the industry to systematically evaluate their current sources of waste generation, waste management practices, and potential waste reduction opportunities that may apply to their plant.

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This report was submitted in fulfillment of Contract No. 85-87151 by ESE under the auspices of the California Department of Health Services.

DISCLAIMER

The statements and conclusions of this report are those of Environmental Science and Engineering, Inc., and not necessarily those of the State of California. The mention of commercial products, their source or their use in connection with material reported herein is not to be construed as either an actual or implied endorsement of such products.

CONTRACTS

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CHAPTER 1.0
SUMMARY AND CONCLUSIONS

In completing this waste audit study, the following objectives were met:

- Evaluated the waste management methods of the pesticide formulating industry;

- Developed recommendations for waste reduction through recycle, treatment, and source reduction; and

- Developed a self audit format checklist to systematically evaluate waste generation by pesticide formulating plants. The checklist outlines waste management practices and waste reduction techniques that apply to formulating operations.

1.1 INDUSTRY DESCRIPTION

Pesticide formulation involves mixing highly concentrated pesticide active ingredients with various diluents and additives to produce convenient-to-use pesticides packaged for the end-user. The product formulations that were included in the scope of this study were agricultural, industrial, and household pesticide formulations. They included:

- Insecticides;
- Herbicides; and
- Rodenticides.

There are three types of pesticide formulations:

- Solvent-based;
- Water-based; and
- Solid-based.

Frequently used carrier solvents in solvent-based formulations are xylene, 1,1,1-trichloroethane, and mineral spirits. Frequently used carrier solids in solid formulations are clays and sand.

The processes used to formulate pesticides generally consist of blending operations where the active ingredients are mixed with the inert ingredients previously mentioned. Generally, chemical reactions and separations do not occur.

Conventional blending equipment is used for pesticide formulation. This equipment includes tanks equipped with mixers for liquid formulations and blending mills for solid formulations. Ancillary equipment includes storage tanks, rotary kilns for curing solid formulations, pumps, hoppers, and conveyors.

Some of the more common hazardous waste streams generated by pesticide formulating operations include:

- Wastewater generated by rinsing of mixing equipment;
- Spent solvent generated by decontamination of mixing equipment;
- Floor wash water;
- Wastewater generated by decontamination of reusable pesticide containers;
- Stormwater runoff from process areas;
- Dust and granule diluents used for flushing of blending equipment;

- Dust emissions from dust/granule formulating mills;

- Inadvertent spillage of pesticide; and

- Empty containers of concentrated pesticides.

1.2 WASTE REDUCTION TECHNIQUES

There are three main types of waste reduction techniques:

- Source reduction;
- Recycling and resource recovery; and
- Waste treatment.

1.2.1 Source Reduction

Source reduction is the prevention of hazardous waste from being created. Source reduction includes the application of good housekeeping, improved operating practices, and process modifications. Examples of the many source reduction options applicable to pesticide formulating operations are listed below.

- Reuse of spent solvent and wastewater from equipment decontamination as makeup in subsequent formulations;

- Reduce the volume of waste and solvent used in equipment decontamination and floor washing by using any of the equipment or methods listed below;

    - High pressure spray nozzles
    - Water knife spray nozzles
    - Portable steam cleaners
    - Wiper blades to physically wipe down sides of mixing tanks
    - Repetitive use of spent solvent and rinse water
    - Mops and squeegees for floor washing

- Reuse of empty containers previously containing concentrated pesticides;

- Install dedicated mixing equipment to optimize reuse of spent rinseate;

- Utilize dedicated vacuum systems to optimize reuse of contaminated dusts;

- Install automatic enclosed cut-in hoppers for bags of concentrated pesticide dusts/granules to minimize fugitive dust emissions;

- Use pumps and piping to transfer liquids to minimize potential for accidental spillage;

- Routine evaluation of waste generation data by management to identify potential areas for waste reduction; and

- Employee waste reduction training programs and incentive compensation for achieving waste reduction goals.

1.2.2 Recycling and Resource Recovery

In the context of waste minimization, recycling and resource recovery usually involve waste treatment to produce a usable substance from a waste. Treatment of wastewater generated by pesticide formulating operations for use/reuse may prove to be a cost effective waste reduction technique at some plants. For example, the collection and treatment of floor wash water or stormwater runoff from process areas for use/reuse as floor wash water or equipment rinse water may prove to be less costly then disposing of these waste streams as a hazardous waste.

Another potentially viable recycling technique for waste reduction is the cleaning of reusable concentrated pesticide containers such as 30- and 55-gallon drums. This would allow sale of the drums to scrap dealers or drum recycling firms, or disposal of the drums as a nonhazardous waste at a Class III landfill. Many pesticide formulating plants use the empty drums without cleaning them. These are used to store and dispose of other hazardous wastes such as pesticide contaminated dusts, empty paper bags, and cartons that previously contained concentrated pesticide dust. However, all such drums may not be able to be reused in this manner. These are dealt with in the following ways:

1. Return to the pesticide supplier for refilling with the same pesticide;

2. Disposal without cleaning as a hazardous waste in a Class I landfill;

3. Triple rinse and dispose of as a nonhazardous waste in a Class III landfill;

4. Ship unrinsed drums to an offsite drum reconditioner;

5. Triple rinse and sell to a scrap dealer or a drum recycling firm for reconditioning; or

6. Triple rinse and recondition onsite.

The viability of recycling used pesticide drums will vary from plant to plant based on site specific conditions. The following economic factors will influence drum recycling.

1. Cost of transporting and disposing of drums at a Class I landfill;

2. Cost of triple rinsing, transporting, and disposing of drums at a Class III landfill, including treatment/disposal cost of rinse water;

3. Income to be realized by sale of triple rinsed drums to scrap dealer or drum recycling firm; and

4. Potential savings that may be realized by onsite reconditioning, and reuse or sale of reconditioned drums.

1.2.3 Treatment Alternatives

The treatment of pesticide-contaminated wastewater can allow reuse of the wastewater in formulating and other associated operations. This is particularly the case when a high purity water is not required. For example, stormwater runoff from process areas can be collected and treated. The treated effluent can be used for floor washing. This may prove to be a cost effective waste reduction technique by reducing disposal costs.

A number of unit operations are treatment technologies commonly used in the pesticides and related industries. Unit operations which provide removal of typical contaminants from pesticide wastewaters include:

- Chemical precipitation;
- Biological treatment;
- Activated carbon adsorption;
- Hydrolysis;
- Chemical oxidation;
- Resin adsorption; and
- Steam or air stripping.

1.3 ECONOMICS

The costs of implementing various waste reduction techniques may initially be high. The savings in disposal costs for hazardous wastes may recover the initial costs in an economical time frame. This payback period for the initial investment in the waste reduction technique will improve as the hazardous waste disposal costs continue to increase. Furthermore, as more types of hazardous waste are banned from landfill disposal, the incentive for waste reduction or complete elimination will become even greater.

Source reduction techniques that rely on new or revised operating practices generally have the least immediate cost because they typically do not require costly capital improvements to plant equipment. However, such a revision in operating procedure may reduce plant efficiency during implementation. The new or revised procedure may also increase labor and other costs. Therefore, a comprehensive economic analysis of capital expenditures, operating costs, and reduction in waste disposal cost should be prepared prior to implementing the change.

Source reduction techniques involving process modifications are usually more costly than operating procedure revisions unless the modification is minor. An example of a minor modification is the installation of spray nozzles on floor washing hoses to increase washing efficiency and minimize wastewater generation. An example of a costly modification is the installation of an enclosed automatic cut-in hopper for bags of pesticide dust to collect fugitive dust emissions for reuse. A typical cost of the latter is about $15,000. Even with this relatively high capital cost, if this pesticide dust formulating mill is used regularly the savings resulting from the reuse of the collected dust emissions may recover the initial cost within an economical payback time.

With regard to recycling and resource recovery, pesticide formulating wastewater can be treated for use/reuse as process water rather than disposing of the wastewater as a hazardous waste. This can reduce disposal costs and be an economically attractive recycling technique. Also, floor wash water or stormwater runoff from process areas can be collected and treated for use/reuse as floor wash water or equipment rinse water. This may prove to be less costly than disposing of these waste streams as a hazardous waste. Factors to be considered in evaluating such a recycle option are listed below:

1. Quantity and quality of raw wastewater.

2. Quantity and quality of water required for intended application.

3. Cost of constructing and operating wastewater collection/treatment system.

4. Cost of disposing of the wastewater as a hazardous waste that would be offset by recycling.

Another important option is the segregation of the various process waste streams. This can improve recyclability and reduce wastewater treatment costs. This would allow use of specialized handling or treatment systems, one for each of the different individual waste streams. This option is often more cost effective than utilizing a large complex treatment system for the combined waste stream.

The costs of wastewater treatment systems vary from plant to plant. Costs depend on the wastewater flow rate, waste characteristics, desired effluent quality, and other parameters. Once the treatment system cost is estimated, it can then be incorporated with other cost components for an economic evaluation of particular waste reduction option being considered.

The treatment of pesticide-contaminated wastewaters as part of a recycling option is generally much more costly than source reduction techniques. Capital costs of treatment systems are commonly in excess of $100,000 and often approach or exceed $1,000,000 for higher wastewater flows. Therefore the overall economic evaluation should include preparation and comparison of all the waste management options available. The final waste management decisions should incorporate the company's business strategy.

1.4 INDIVIDUAL AUDIT FINDINGS AND CONCLUSIONS

The findings of the audits of the three pesticide formulating plants are summarized below.

- Plant A formulates three different dust/granule form herbicide/fertilizer mixtures.

- Plant B formulates only xylene-based pesticides with malathion and diazinon as the active ingredients.

- Plant C formulates over 600 different pesticide formulations that are water-, solvent-, and solid-based formulations using a wide variety of active pesticide ingredients.

- Plants A, B, and C are currently practicing waste reduction. Reduction methods include reuse of vacuum system dust, and reuse of wastewater and solvent from mixing equipment decontamination. These wastes are used in subsequent pesticide formulations.

- At Plant B, the mixing tanks used for formulating pesticides are decontaminated by solvent rinsing. The tanks are currently wiped down with rags as a final means of decontamination. The rags must be disposed of after use. To avoid the disposal costs, a pressurized solvent sprayer and squeegees can be used for final decontamination. The spent solvent can be reused. This would eliminate waste generation of solvent rinsings and rags. This technique would require capital and additional operating costs of approximately $200 and $150 per year, respectively.

- The most prominent waste minimization techniques implemented at Plant C are those which control the generation of hazardous dusts in the formulation of dust and granular pesticides.
  These techniques are listed below:

  - Installation of dedicated dust collection baghouses on each dust/granule formulating mill;

  - Installation of enclosed cut-in hoppers, conveyors, elevators, mixers, and holding tanks;

  - Recycling of dust collected from each mill component to the preceding component;

  - Reuse of dust collected in the baghouse hopper for subsequent formulations.

- Any empty 55-gal drum which previously contained pesticide at Plant C is either reused for collecting hazardous waste, or washed and shipped to an offsite drum recycler. Drums shipped to the offsite recycler are first steam cleaned.

- Waste reduction measures that have been implemented relative to liquid process wastes at Plant C include:
  - Use of portable steam cleaners to clean mixing tanks rather than using the batch-boil method;
  - Use of spray nozzles on hoses used for rinsing mixing and other process equipment, and floor washing; and
  - Recycling of equipment rinse waster as diluent for subsequent formulations when practicable.
- Many of the higher strength process wastewaters at Plant C, such as equipment rinse water, are generated in almost negligible volumes. This is in comparison to the volume of plant stormwater runoff that is collected and handled as a hazardous waste. Consequently, any source reduction of process wastewaters that have been implemented are masked by commingling with the large volume of stormwater runoff.
- The higher strength process waste streams at Plant C could be segregated from the lower strength streams, particularly stormwater runoff. Such lower strength streams could be treated for reuse in the plant. The benefits could be significant considering the high cost of disposing of the wastewater at a Class I hazardous waste management facility.

CHAPTER 2.0
INTRODUCTION

2.1 STUDY OBJECTIVES

This study evaluated waste management methods in the pesticide formulating industry. It developed recommendations for waste reduction through recycle, treatment, and source reduction. This study is part of a broad program at the State of California Department of Health Services to reduce the quantity of hazardous waste generated in California. The study supports the State mandate to phase out land disposal of hazardous wastes. The information of this study was obtained primarily by conducting audits of pesticide formulating plants. The study also developed a format for conducting self audits. The self audit format serves as a checklist for the industry to systematically evaluate waste generation and waste reduction techniques that may apply to their plants. This report presents the findings of this study by describing applicable waste reduction techniques through source reduction (Chapter 4.0), recycling and resource recovery (Chapter 5.0), and treatment (Chapter 6.0). The economics of implementing these techniques are addressed in Chapter 7.0. The appendices contain the individual plant audit reports, a summary of the plant audits, and the self audit format.

2.2 GENERAL DESCRIPTION OF PESTICIDE FORMULATING INDUSTRY

Pesticide formulation converts highly concentrated pesticide active ingredients into convenient-to-use products at application concentrations packaged for the end-user. The technical pesticide chemical is formulated with:

1. Other pesticides;
2. Non-pesticide synergists;
3. Propellants;
4. Inert diluents; and

5. Functional additives to modify the physical state of the product. These additives preserve, disperse, color, or impart other desirable properties to the pesticide formulation.

The product formulations that were included in the scope of this study were agricultural, industrial, and household pesticide formulations. These include insecticides, herbicides, and rodenticides. Excluded from the study were preservatives, disinfectants, and cleaning agents.

There are three types of pesticide formulations; solvent-based, water-based, and solid-based. In solvent-based formulations, the solvent serves as the carrier solution for the pesticide ingredient. A solvent-water emulsion may also be used as the carrier. Typical solvents are light aromatics such as xylene, chlorinated organics such as 1, 1, 1-trichloroethane, and mineral spirits. As with solvent-based formulations, water serves as the carrier solution for the active pesticide ingredient in the water-based formulations. Other water-based formulations are in the form of suspensions or emulsions. The solvent- and water-based formulations are applied directly in the liquid form or propelled as an aerosol.

There are many types of dry based pesticide formulations prepared by blending solid active ingredients with inert solids such as clay and sand. Some dry formulations are prepared by absorbing liquid active ingredients with solid carrier materials. Some common dry-based formulations are:

1. Dusts,
2. Wettable powders,
3. Granules,

4. Treated seed, and
5. Bait pellets and cubes.

The processes used to formulate pesticides generally consist of blending operations where the active ingredients are mixed with the inert ingredients previously mentioned. Also, particle size reduction operations such as milling and coating operations for granule and treated seed production are used. Generally, chemical reactions and separations do not occur.

Conventional blending equipment is used for pesticide formulation. This equipment includes tanks equipped with mixers for liquid formulations and blending mills for solid formulations. Ancillary equipment includes storage tanks, rotary kilns for curing solid formulations, pumps, hoppers, and conveyors. Mixing tank capacities generally vary from less than 100 gallons to several thousand gallons for liquid formulations. Solids blending mill capacities are usually on the order of several hundred pounds to 1 ton.

Packaging of the pesticides formulations most commonly occurs at the same plant where the formulating is performed. This avoids the cost of transporting the high volume, dilute formulations. Packaging generally involves pouring liquid formulations into 55-gallon drums or glass bottles for distribution. For solid formulations, the material is usually gravity fed from hoppers into drums or paper bags for distribution.

2.3 STUDY METHODOLOGY

The primary method utilized in the study was the performance of audits of pesticide formulating plants. Additional information was also gathered by conducting a literature review.

The objectives of the plant audits were to:

1. Gather site specific information concerning the generation, handling, storage, treatment, and disposal of hazardous waste;
2. Evaluate existing waste reduction practices;
3. Develop recommendations for waste reduction through source control, treatment, and recycling techniques; and
4. Assess costs/benefits of existing and recommended waste reduction techniques.

The first step in conducting the audits was selecting and contacting the plants to solicit their voluntary participation. Plant selection emphasized small businesses which generally lack the financial and/or internal technical resources to perform a waste reduction audit. One relatively large plant was also selected for study. This plant offered the opportunity to evaluate a wide variety of pesticide formulating operations, as well as a number of in-place waste reduction measures. A total of three plants were audited. Appendices A through C contain the individual plant audit reports. Appendix D contains a summary of the plant audits.

During each of the plant audits, the audit team performed the following functions:

- Observed pesticide formulating operations;
- Inspected waste management facilities;
- Interviewed the plant manager, environmental compliance personnel, and operations supervisors; and
- Reviewed and copied records pertinent to waste generation and management.

The audits were performed by one or two engineers. Each audit required one to three days, depending on the size and complexity of the formulating and waste management operations.

CHAPTER 3.0

CURRENT REGULATORY ASPECTS

In this chapter, the various regulations relevant to the pesticide formulating industry are presented. A list of the various regulatory agencies is also provided.

3.1 LAWS AND REGULATIONS RELEVANT TO PESTICIDE FORMULATION

Table 3-1 contains a list of federal and state laws and regulations that are relevant to the pesticide formulating industry. The list contains existing and pending legislation on raw material handling, pesticide registration, waste management, air quality, discharge to sewer, and worker safety.

The principal new concern among pesticide formulators at present is the November 8, 1986 federal restriction on the land disposal of halogenated and non-halogenated solvent wastes. Restricted solvent wastes are numbered F001-F005 as defined in Section 261.31, Title 40, Code of Federal Regulations. Solvent wastes generally result from the use of solvents to decontaminate pesticide formulation equipment. The restriction is mandated by the Federal 1984 Hazardous and Solid Waste Amendments (HSWA) to RCRA. However, these amendments provide options for a delay of up to two years in the implementation of the restriction. On November 7, 1986, EPA announced a conditional extension on the implementation. According to the modified restriction, solvent wastes were prohibited from land disposal starting on November 8, 1986, unless one or more of the following conditions applies:

(1) The generator of the solvent waste is a small quantity generator of 100-1000 Kgs/month of hazardous waste.

Table 3-1. Selected * Codes and Regulations (page 1 of 6)

Category	**Regulation/Rule**	**Description**
Air Quality	BAAQMD Regulation 8, Rule 35 KCAPCD Rule 410 MBUAPCD Rule 416 SCAQMD Rule 317 SCAQMD Rule 442 SLOCAPCD Rule 407 H (1)	Restricts discharge of organic materials into the atmosphere from equipment in which solvents are used.
	SCAQMD Rule 443	Requires coatings and solvents to be labeled to indicate their photochemical reactivity.
	BAAQMD Regulation 8, Rule 5	Deals with the storage of organic liquids.
	KCAPCD Rule 413 MBUAPCD Rule 429	Deals with organic liquid loading.
	BAAQMD Regulation 8, Rule 39 KCAPCD Rule 410.2 SBAQMD Rule 324 SLOCAPCD Rule 407 H (4)	Deals with the disposal and evaporation of solvents.
Solvent storage	CAC Title 23, Chapter 3, Subchapter 16	Underground storage of solvents.
	CHSC Division 20, Chapter 6.7	Regulates underground storage of hazardous substances.
	CAC Title 22, Division 4, Ch. 30, Article 24	Regulates the use and management of containers.
	CHSC Chapter 6.95	Requires local government agencies to implement hazardous material management programs requiring local businesses to submit business plans and inventories for the storage and handling of hazardous materials.

Table 3-1. Selected * Codes and Regulations (Continued, page 2 of 6)

Category	Regulation/Rule	Description
Solvent storage (Continued)	CAC Title 22, Chapter 30, Article 6	Sets requirements for generators of hazardous wastes including restrictions on how long wastes can be accumulated without the storage facility being permitted.
	CHSC 25123.3	Definition of storage.
Wastewater discharge	Clean Water Act 32 U.S.C. 1251 et seq.	Water quality control for wastewater disposed in surface waters, municipal sewers, and injection well.
	Safe Drinking Water Act. 40 CFR 141	Water quality control for wastewater disposed in surface waters, municipal sewers, and injection well.
	NPDES regulations 40 CFR 122	Regulations on the reduction of pollutant discharges into the waters of the United States.
	CAC Title 23 Subchapter 9	State regulations governing the discharge of wastewaters to surface waters. Includes provisions for issuance of permits and setting effluent limitations.
	Local municipal codes addressing discharges to POTWs	Discharge requirements set by local POTWs restricting the concentrations of pollutants in wastewaters discharged to sanitary sewers.

Table 3-1. Selected * Codes and Regulations (Continued, page 3 of 6)

Category	Regulation/Rule	Description	Remarks
Waste treatment, recycle, or disposal	CHSC 25175	Authorizes DHS to provide a listing of recyclable hazardous wastes found by DHS to be economically and technically feasible to recycle. Also authorizes fee penalties for failure to do so, as specified.	The list is in Title 22, CAC 66796. The method is in Title 22, CAC 66763.
	Title 22, CAC 66796	Provides a list of recyclable wastes and suggests methods for recycle.	List for CHSC 25175
	Title 22, CAC 66763	If a "recyclable" waste is disposed then DHS may request the generator to explain why the waste was not recycled. The generator must respond.	Method for CHSC 25175
	CHSC 25190	Sanctions specified for generator non-compliance with the regulations.	
	CHSC 25186 (c)	Sanctions specified for facilities with permits, non-compliance with the regulations.	
	CHSC 25155.5 (a)	Requires incineration or equivalent treatment of hazardous wastes with greater than 3000 BTU/lb.	Existing law becomes effective in 1988
	CHSC 25155.5 (b)	Requires incineration or equivalent treatment of hazardous wastes containing volatile organic compounds in concentrations exceeding standards to be determined by DHS.	Existing law becomes effective in 1990.

Table 3-1. Selected * Codes and Regulations (Continued, page 4 of 6)

Category	Regulation/Rule	Description	Remarks
Waste treatment, recycle, or disposal (Continued)	CHSC 25208.4	Prohibits discharge of any liquid hazardous waste into a surface impoundment located within 1/2 mile of a potential source of drinking water. Contains important exemption provisions.	Effective June 30, 1988
	CHSC 25202.9	Requires annual certification by hazardous waste generators who operate TSD onsite facilities that they have a waste minimization program in operation. Further, they must certify that the treatment, storage, or disposal methods minimize threats to human health and environment.	
	CHSC 25244.4	Generators are required to submit a report every two years on waste reduction status.	
	CHSC 25179	Would prohibit land disposal of all untreated hazardous wastes	Effective 1990
	40 CFR 165	Recommended procedures for the disposal and storage of pesticides and pesticide containers.	
	32A CFR 650	Hazard and toxic materials management (bibliography and tables).	

Table 3-1. Selected * Codes and Regulations (Continued, page 5 of 6)

Category	Regulation/Rule	Description	Remarks
Land disposal	CHSC 25122.7 and Title 22 CAC 66900-66935	Specifies land disposal restrictions. List therein of restricted hazardous wastes which includes wastes containing more than 1000 mg/kg of halogenated organic compounds.	Effective 1/1/85 for liquid halogenated organics and postponed to 7/8/89 for organic sludges and solids containing halogenated compounds.
	40 CFR 264.314 (b)	Prohibits land disposal of bulk or noncontainerized liquid hazardous waste or hazardous waste containing free liquids.	Effective May 8, 1985.
	RCRA 3004(e)(1)	Prohibits land disposal of most solvents unless treatment levels (2 ppm for most constituents) are met.	Effective November 8, 1986.
	40 CFR 268.3	Prohibits land disposal of dilute wastewaters containing solvents and having 1% or less total organics.	Effective November 8, 1988.
Other	Title 3 CAC Chapter 6, Subchapter 3	Pest control operations, licensing, work requirements, and pesticide worker safety.	

Abbreviations:
APCD - Air Pollution Control District
AQMD - Air Quality Management District
BA - Bay Area
BTU - British Thermal Units
CAC - California Administrative Code
CFR - Code of Federal Regulations
CHSC - California Health and Safety Code
DHS - Department of Health Services
KC - Kern County
MBU - Monterey Bay Unified

Table 3-1. Selected * Codes and Regulations (Continued, page 6 of 6)

Abbreviations (Continued):

NPDES- National Pollutant Discharge Elimination System
POTW - Publicly Owned Treatment Works
RCRA - Resource Conservation and Recovery Act
SB - Santa Barbara
SC - South Coast
SLOC - San Luis Obispo County
TSD - Treatment, Storage, or Disposal
USC - United States Congress
VOC - Volatile Organic Compounds

* **The generator should contact the appropriate local, state, or federal authority for complete, detailed, and updated regulatory information.**

Source: Jacobs Engineering Group, Inc. 1987; and ESE, 1987.

(2) The waste contains less than 1 percent total of F001-F005 solvent constituents.

(3) The solvent waste is generated due to cleanup or other remedial action taken under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended.

However, the solvent wastes listed in Items 1 to 3 above will be restricted from land disposal effective November 8, 1988. In the meantime, these wastes may be disposed in a landfill that is in compliance with the requirements specified in EPA regulations. Dilution of the wastes as a means of meeting the requirement in Item 2 above is prohibited under EPA regulations.

3.2 REGULATORY AGENCIES

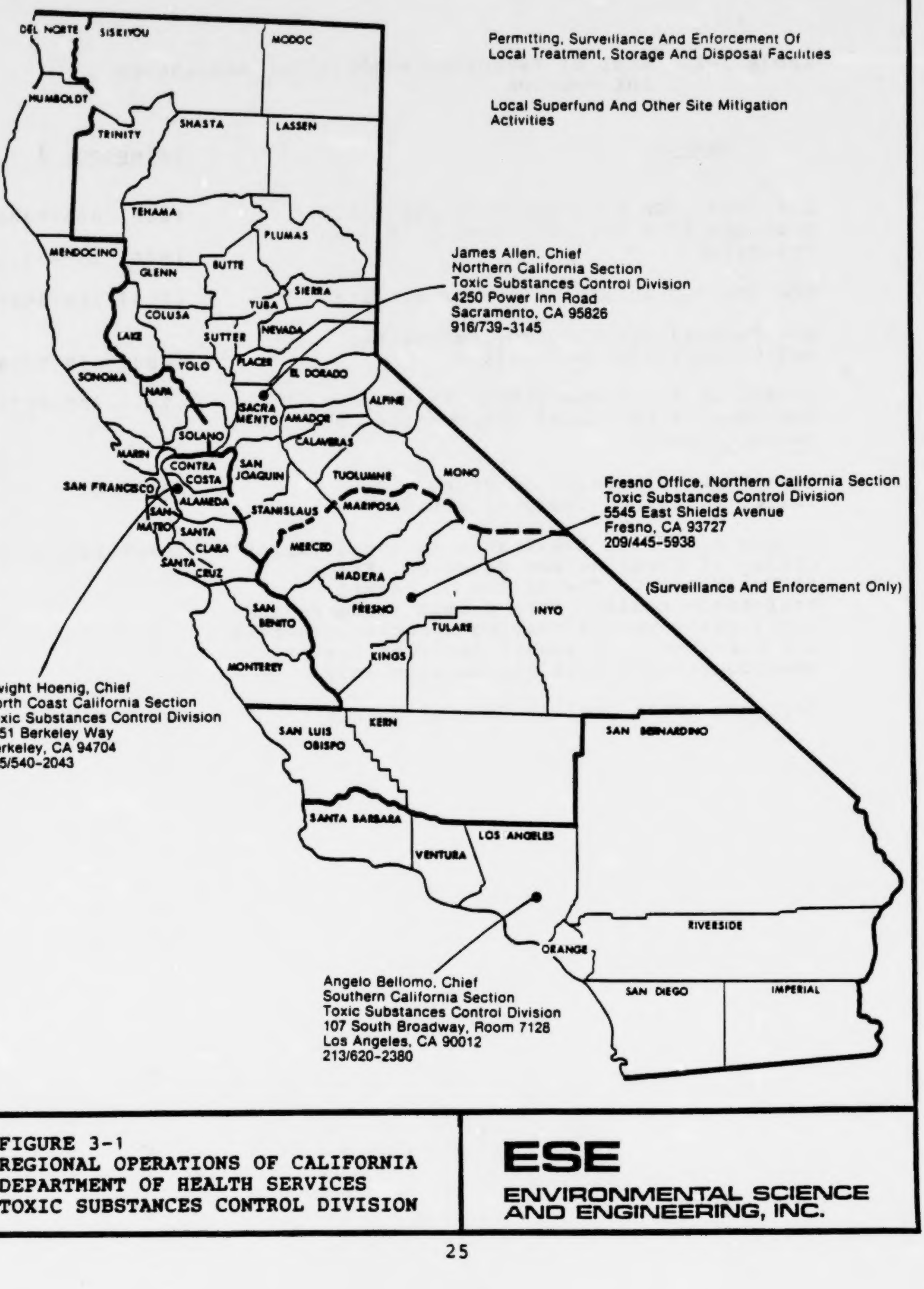
Table 3-2 and Figures 3-1 and 3-2 identify the regulatory agencies that may be contacted with questions on the handling and disposal of pesticide formulating wastes.

Table 3-2. List of Telephone Numbers for Regulatory Information

Agency	Telephone #
U.S. EPA RCRA Hotline, Washington D.C.	(800) 424-9346
U.S. EPA RCRA Hotline, Region IX, San Francisco	(800) 231-3075
EPA Small Quantity Generator Hotline	(800) 368-5888
EPA Federal Insecticide, Fungicide, and Rodenticide Act Hotline	(800) 858-7378
Office of Solid Waste EPA, Washington, D.C. Can provide technical information on solvent waste disposal.	(202) 382-4770
Department of Health Services Toxics Division, regional offices	See Figure 3-1
Office of Permit Assistance in the Governor's Office of Planning and Research, State of California. The Office of Permit Assistance assists with permit issuance and cataloguing permit issuing agencies, whereas the Department of Health Services issues hazardous waste facility permits only.	(916) 322-4245
Regional Water Quality Control Boards	See Figure 3-2

Permitting, Surveillance And Enforcement Of Local Treatment, Storage And Disposal Facilities

Local Superfund And Other Site Mitigation Activities


DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
YUBA
COLUSA
NEVADA
SUTTER
LAKE
PLACER
YOLO
EL DORADO
SONOMA
NAPA
SACRA MENTO
ALPINE
AMADOR
SOLANO
CALAVERAS
MARIN
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
MONO
SAN FRANCISCO
ALAMEDA
STANISLAUS
MARIPOSA
SAN MATEO
SANTA CLARA
MERCED
SANTA CRUZ
MADERA
SAN BENITO
FRESNO
INYO
TULARE
KINGS
MONTEREY
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
RIVERSIDE
ORANGE
SAN DIEGO
IMPERIAL

James Allen, Chief
Northern California Section
Toxic Substances Control Division
4250 Power Inn Road
Sacramento, CA 95826
916/739-3145

Fresno Office, Northern California Section
Toxic Substances Control Division
5545 East Shields Avenue
Fresno, CA 93727
209/445-5938

(Surveillance And Enforcement Only)

Dwight Hoenig, Chief
North Coast California Section
Toxic Substances Control Division
2151 Berkeley Way
Berkeley, CA 94704
415/540-2043

Angelo Bellomo, Chief
Southern California Section
Toxic Substances Control Division
107 South Broadway, Room 7128
Los Angeles, CA 90012
213/620-2380

FIGURE 3-1
REGIONAL OPERATIONS OF CALIFORNIA
DEPARTMENT OF HEALTH SERVICES
TOXIC SUBSTANCES CONTROL DIVISION

ESE
ENVIRONMENTAL SCIENCE
AND ENGINEERING, INC.

NORTH COAST REGION (1)
1000 Coddingtown Center
Santa Rosa, California 95401
(707) 576-2220

SAN FRANCISCO BAY REGION (2)
1111 Jackson Street, Room 6040
Oakland, California 94607
(415) 464-1255

CENTRAL COAST REGION (3)
1102-A Laurel Lane
San Luis Obispo, California 93401
(805) 549-3147

LOS ANGELES REGION (4)
107 South Broadway, Room 4027
Los Angeles, California 90012
(213) 620-4460

CENTRAL VALLEY REGION (5)
3443 Routier Road
Sacramento, California 95827
(916) 361-5600

Fresno Branch Office
3614 East Ashland Ave.
Fresno, California 93726
(209) 445-5116

Redding Branch Office
100 East Cypress Avenue
Redding, California 96002
(916) 225-2045

LAHONTAN REGION (6)
2092 Lake Tahoe Boulevard
P. O. Box 9428
South Lake Tahoe, California 95731
(916) 544-3481

Victorville Branch Office
15371 Bonanza Road
Victorville, California 92392
(619) 245-6583

COLORADO RIVER BASIN REGION (7)
73-271 Highway 111, Suite 21
Palm Desert, California 92260
(619) 346-7491

SANTA ANA REGION (8)
6809 Indiana Avenue, Ste. 200
Riverside, California 92506
(714) 684-9330

SAN DIEGO REGION (9)
6154 Mission Gorge Road, Suite 205
San Diego, California 92120
(619) 265-5114

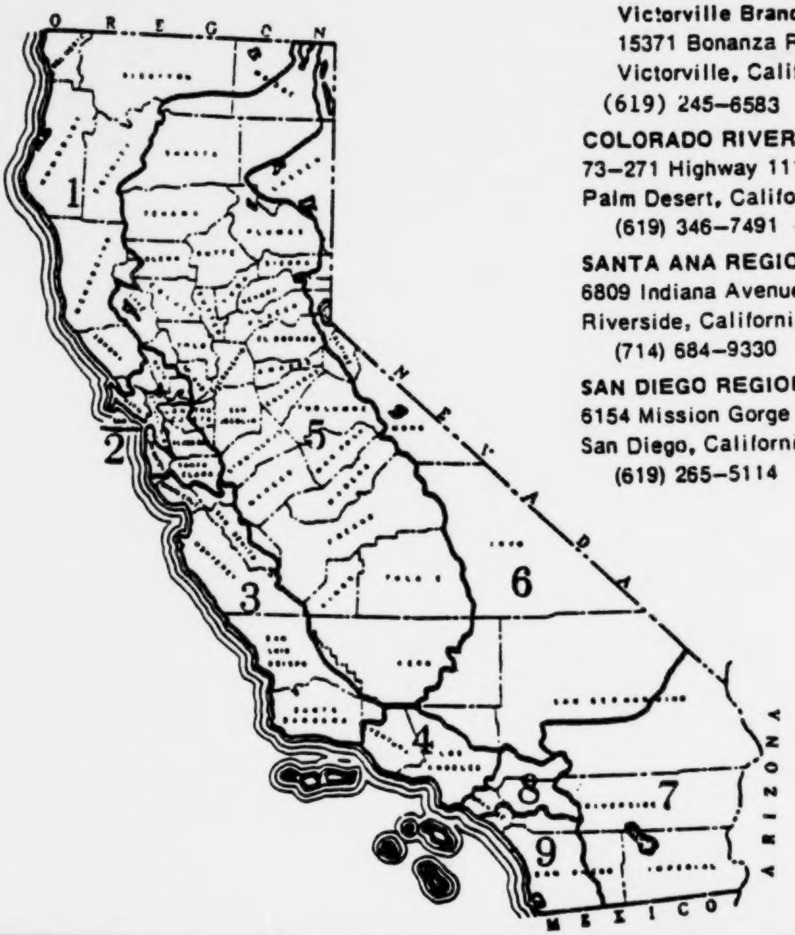


FIGURE 3-2
CALIFORNIA REGIONAL WATER
QUALITY CONTROL BOARDS

ESE
ENVIRONMENTAL SCIENCE
AND ENGINEERING, INC.

CHAPTER 4.0

SOURCE REDUCTION

Source reduction consists of any measure that reduces or eliminates the generation of a hazardous waste by an industrial process. One measure, product substitution means replacing one or more raw materials with other suitable materials, or replacing the original product with another suitable product to effect a reduction or elimination in hazardous waste generation. Source reduction also involves the application of good housekeeping, sound operating practices, or process modifications to reduce or eliminate hazardous waste generation.

4.1 SOURCES OF WASTE GENERATION

In order to present a meaningful discussion of source reduction techniques that are applicable to the pesticide formulating industry, the sources of waste generation in this industrial segment must first be described. As described in Chapter 2.0, pesticide formulating generally involves the blending of concentrated active pesticide ingredients with inert diluents, and the actual formulation process typically does not generate wastes. However, related non-formulating activities do generate hazardous wastes. These include decontamination of mixing and storage equipment, housekeeping operations, and laboratory testing for quality assurance. Tables 4-1 and 4-2 describe the various sources of liquid and solid hazardous wastes. As shown in Table 4-1, decontamination of liquid pesticide mixing and storage equipment generates pesticide-contaminated wastewater or solvent, depending upon whether the equipment is used to formulate water or solvent-based pesticides. Decontamination is performed in-between batches of different types of

Table 4-1. Sources of Liquid Hazardous Waste in the Pesticide Formulating Industry (page 1 of 2)

Operation/Source	Waste Type
Decontamination of mixing/ storage equipment	Liquid cleaner (water or solvent) contaminated with pesticide
Floor washing to clean up spills	Pesticide-contaminated wastewater
Decontamination of reusable active ingredients containers	Pesticide-contaminated wastewater
Control of air emissions from formulating areas	Pesticide-contaminated scrubber water
Laboratory analyses of formulations for quality control	Pesticide-contaminated wastewater and solvents
Laundering of protective clothing for operational personnel	Pesticide-contaminated laundry wastewater
Stormwater runoff from process areas	Pesticide-contaminated runoff as a result of pesticide spillage and fallout of pesticide dust in process areas

Table 4-1. Sources of Liquid Hazardous Waste in the Pesticide Formulating Industry (Continued, page 2 of 2)

Operation/Source	Waste Type
Cooling tower blowdown	Pesticide-contaminated blowdown as a result of entrainment of pesticide dust
Hot water bath for leak checking of aerosol containers	Pesticide-contaminated wastewater when aerosol leakage occurs

Table 4-2. Sources of Solid Hazardous Waste in the Pesticide Formulating Industry

Operation/Source	Waste Type
Decontamination of blending mills	Inert dust/granule diluent (clay and sand) contaminated with pesticide
Vacuuming of dust from mills and process area	Pesticide-contaminated dust
Inadvertent spillage of concentrated pesticides	Pesticide-contaminated dust/granules
Empty containers of concentrated pesticides	Paper bags; and steel, plastic, and fiber drums contaminated with pesticides
Control of air emissions from liquid formulating areas	Pesticide-contaminated activated carbon filters
Laboratory analysis	Pesticide-contaminated dusts/granules

formulations to prevent cross contamination of the subsequent batch. Decontamination is also performed prior to taking the equipment out of service for maintenance. The decontamination is commonly performed using high pressure water hoses equipped with spray nozzles, portable steam jennies, or by running a batch of solvent through the formulating equipment.

Floor washing is typically performed using water hoses equipped with spray nozzles. It may also involve the use of mops and squeegees.

Reusable active ingredient containers, such as 55-gallon drums, are often decontaminated by triple rinsing. They then can be sold or given to commercial recycling firms. The decontamination is usually performed using a high pressure water hose equipped with a spray nozzle or a portable steam jenny.

Another source of liquid waste, unique to the packaging of aerosol pesticides, is the hot water bath. This is required by the U.S. Department of Transportation to check for leaking cans (49B CFR Part 178). Each filled aerosol can is immersed in the bath where bubbles can be seen if a container has not been sealed. Water from the hot water baths is discharged routinely to prevent turbidity.

As shown in Table 4-2, decontamination of the solid-based pesticide blending mills generates solid diluent contaminated with pesticides. The diluent typically consists of clay for dust mills and sand for granule mills. Decontamination of the blending equipment is performed for the same reasons as for the liquid pesticide formulating equipment. It is accomplished by running a batch of the inert diluent through the blending equipment.

Most dust/granule blending mills are equipped with vacuum systems to collect fugitive dust. This provides for worker safety, control of product loss, and for housekeeping in the process area. Some vacuum systems are dedicated to certain mills to facilitate reuse of the dust. Other systems are used to collect dust from a number of areas.

4.2 SOURCE REDUCTION TECHNIQUES

Source reduction through product substitution is not an easily implemented procedure. This is because of the high level of effort and cost associated with registering a new pesticide with EPA as required by the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Registration of a new pesticide is required before it may be bought, sold, distributed, or otherwise handled. Pesticide registration involves the development and submission of a health and ecological risk database to EPA for review. In 1986, EPA proposed to increase the pesticide registration fees to as high as $163,100 for a new chemical. In addition to pesticide registration with EPA, registration with the State of California is also required in accordance with the Food and Agriculture Code of the state laws and Title 3, California Administrative Code. The California registration application must include the EPA stamped and approved product label and the EPA letter of acceptance.

Consequently, the waste reduction study of the pesticide formulating industry focused on source reduction that relies on good operating practices and process modifications. General examples of good operating practices and process modifications are listed in Table 4-3. Tables 4-4 and 4-5 present specific examples. The installation of flow measuring equipment can monitor water usage. Solids weighing equipment can monitor the usage of dust/granule mill flushing media. This equipment is vital to ongoing evaluation of waste

reduction efforts, employee training, and monitoring trial implementation of new waste reduction techniques.

Table 4-3. Good Operating Practices and Process Modifications

Good Operating Practices		Process Modification	
1.	Material handling improvements	1.	Improved controls
		2.	Increased automation
2.	Management initiatives	3.	Minimized water use
3.	Employee training	4.	Minimized solvent use
4.	Scheduling improvements	5.	Counter-current rinse
5.	Spill and leak prevention	6.	Rinse/wash medium reuse
6.	Preventive maintenance		
7.	Waste/material tracking	7.	Internal recycle
8.	Process and operation documentation		
9.	Waste segregation		

Source: Fromm and Callahan, 1986.

Table 4-4. Specific Examples of Good Operating Practices in the Pesticide Formulating Industry (page 1 of 3)

	General Practice	Specific Example
1.	Material handling improvements	Use of pumps and piping to transfer liquids, rather than transporting in bulk containers to minimize potential for accidental spillage.
2.	Management initiatives	Routine evaluation of waste generation data relative to formulation activities to identify potential areas for waste reduction.
3.	Employee training	Involve employees from the outset of trial implementation of waste reduction techniques such as reuse of spent rinse water in equipment decontamination. Establishment of waste reduction goals and routine employee training. Employee incentive compensation for waste management savings.

Table 4-4. Specific Examples of Good Operating Practices in the Pesticide Formulating Industry (Continued, page 2 of 3)

	General Practice	Specific Example
4.	Scheduling improvements/ batch sequencing	Maximize the number of consecutive batches of the same or similar formulations to minimize the amount of mixing equipment decontamination required between different formulations.
5.	Spill or leak prevention	Improve worker access to dispensing equipment used in packaging pesticide formulations to minimize potential for accidental spillage.
6.	Preventive maintenance	Routinely check condition of formulating and packaging equipment to identify and repair damaged or corroded areas which may cause leakage.
7.	Waste/material tracking	Keep up-to-date records on type and quantities of used rinsing/flushing media to optimize reuse of the media for rinsing/

Table 4-4. Specific Examples of Good Operating Practices in the Pesticide Formulating Industry (Continued, page 3 of 3)

	General Practice	Specific Example
7.	Waste/material tracking (continued)	flushing or as a diluent in subsequent formulations. Computer-controlled inventory of raw materials, wastes, and products to optimize reuse of wastes and minimize obsolete stock.
8.	Process and operation	Keep operating logs for dust/granule blending mills to document flushing frequency, quantity of flushing medium used, quantity of flushing medium requiring disposal and cost of flushing operation. Review logs periodically to evaluate success of flushing medium reuse.
9.	Waste segregation	Utilize dedicated vacuum systems where possible to minimize the contamination of dusts.

Table 4-5. Specific Examples of Process Modifications in the Pesticide Formulating Industry (page 1 of 3)

	General Practice	Specific Example
1.	Improved controls	Installation of easily controlled spray nozzles on equipment rinsing and floor washing hoses to increase rinsing/washing efficiency and minimize wastewater generation. Installation of high-pressure water knife spray nozzles to reduce dilution and allow reuse of rinseate.
2.	Increased automation	Installation of automatic enclosed cut-in hoppers for bags of concentrated pesticide dust. Reduces dust emission potential associated with manual opening and emptying of pesticide dust containers.
3.	Minimized water use	Collect and reuse spent rinse water for subsequent rinsing or pesticide formulation.

Table 4-5. Specific Examples of Process Modifications in the Pesticide Formulating Industry (Continued, page 2 of 3)

	General Practice	Specific Example
4.	Minimized solvent use	Collect and reuse spent rinse solvent for subsequent rinsing or pesticide formulation.
5.	Counter-current rinse	Installation of vacuum systems on dust/granule mills that draw dust emissions off the various mill components counter-current to flow of formulation. For example, dust drawn from the mixer is routed to the enclosed cut-in hopper.
6.	Rinse/wash medium reuse	Reuse liquid pesticide mixing equipment rinse water and flushing medium for dust/granule pesticide mills in subsequent formulations or for subsequent rinsing/flushing operations. Use of improved equipment cleaning techniques and installation of dedicated equipment to optimize reuse of spent rinseate.

Table 4-5. Specific Examples of Process Modifications in the Pesticide Formulating Industry (Continued, page 3 of 3)

	General Practice	Specific Example
7.	Internal recycle	Collect accidental spillage from packaged materials awaiting distribution and reuse in formulating/packaging operations.

CHAPTER 5.0

RECYCLING AND RESOURCE RECOVERY

In the context of waste minimization, recycling and resource recovery usually involve waste treatment to produce a usable substance from a waste. This substance can then be used in the manufacture or formulation of a product. As a result, hazardous waste generation is reduced. As depicted in Figure 5-1, there are two categories of recycling and resource recovery: 1) use/reuse; and 2) reclamation. Use/reuse involve waste treatment to produce a material that can be reused as a raw material in the industrial process that originally generated the waste. Alternatively, the material can be used as a raw material in a different industrial process. Reclamation involve waste treatment to recover the product of the industrial process that originally generated the waste. Or, reclamation can be used to produce an entirely different usable product from the waste.

Used formulating equipment rinsing/flushing media is often used as makeup diluent for subsequent pesticide formulations without treatment. Likewise, dust collected by vacuum systems dedicated to certain formulation areas is often reused in subsequent formulations without treatment. The reuse of these wastes without treatment is possible because they are not contaminated with other contaminants that would render them unusable for formulating. However, other wastes generated by pesticide formulating operations are likely to contain other contaminants. Of these, solid wastes generally cannot be treated cost effectively to provide use or reuse of the solid wastes. However, treatment of pesticide formulating wastewater for use/reuse may be cost effective at some pesticide formulating plants. For example, floor wash water or stormwater runoff from process areas can be collected and treated for use/reuse as floor wash water or equipment rinse

FIGURE 5-1
RECYCLING AND RESOURCE RECOVERY TECHNIQUES

SOURCE: JACOBS ENGINEERING GROUP, INC., 1986 water. This may be less costly than hazardous waste disposal of these wastes. Such a recycle option should evaluate:

1. Quantity and quality of raw wastewater.
2. Quantity and quality of water required for intended application.
3. Cost of constructing and operating wastewater collection/treatment system.
4. Cost of disposing of the wastewater as a hazardous waste that would be recovered by recycling.
5. Cost of process water that would be reduced due to wastewater reuse.

The treatment of wastes generated by pesticide formulating operations to recover usable pesticide compounds is not a commonly used recycling technique. This is because of the rigid quality control requirements for the pesticide formulations, and the lack of cost effective treatment technologies to recover usable compounds from the wastes.

Pesticide ingredient containers can be cleaned for reuse or nonhazardous waste disposal. These include thirty and fifty-five gallon drums. Many pesticide formulating plants use the uncleaned empty drums to store and dispose of other hazardous wastes such as pesticide contaminated dusts and empty paper bags and cartons. Generally the following options exist for container waste management:

1. Return to the pesticide supplier for refilling with the same pesticide;

2. Disposal without cleaning as a hazardous waste in a Class I landfill;

3. Triple rinse and dispose of as a nonhazardous waste in a Class III landfill;

4. Ship unrinsed drums to an offsite drum reconditioner;

5. Triple rinse and sell to a scrap dealer or a drum recycling firm for reconditioning; or

6. Triple rinse and recondition onsite.

Option 1 described above can be very economical. However, some pesticide suppliers will not accept used drums from all formulators. Option 2 is hazardous waste disposal. One disadvantage is the long-term liability imposed on the waste generator. Option 3 generates spent rinse water which is hazardous waste. This is a disadvantage if the spent rinse water cannot be reused in pesticide formulation. Option 4 imposes liability upon the waste generator because the pesticide-contaminated drums leave his control. As with Option 3, Options 5 and 6 also require management of spent drum rinse water. Furthermore, the drum reconditioning in Option 6 is costly and normally involves other waste generating operations such as paint stripping and painting.

At present, two Class I landfills in the State of California accept pesticide-contaminated drums: 1) the Chemical Waste Management, Inc. facility near Kettleman City in Kings County; and 2) the Kenneth Hunter, Jr. facility near Casmalia in Santa Barbara County.

Triple rinsing of the drums is usually performed using a water hose equipped with a spray nozzle, or more effectively with steam. The volume of wastewater generated by the triple rinsing typically varies from about 10 to 20 gallons per drum. The wastewater is a hazardous waste. Drums are reconditioned onsite usually by triple rinsing, firing to about 1200°C, sand-blasting, and repainting. Reconditioned containers may be reused for the same chemical class of pesticides previously contained, and could therefore be used to contain pesticide formulations. By regulation (40 CFR Part 162.10), they could not be reused to contain food, animal feed, beverages, drugs, or cosmetics.

The viability of recycling used pesticide drums will vary from plant to plant based on site specific conditions. The following factors will influence the viability of drum recycling.

1. Cost of transporting and disposing of drums at a Class I landfill;

2. Cost of triple rinsing, transporting, and disposing of drums at a Class III landfill, including treatment/disposal cost of rinse water;

3. Income to be realized by sale of triple rinsed drums to scrap dealer or drum recycling firm; and

4. Potential savings that may be realized by onsite reconditioning, and reuse or sale of reconditioned drums.

CHAPTER 6.0
PRINCIPAL TREATMENT ALTERNATIVES

Wastewater treatment minimizes waste by reducing the toxicity of the wastewater. Wastewater treatment can also facilitate reuse of the wastewater for formulating, mixing equipment rinsing, and floor washing. Conventional process technology unit operations are commonly used to treat wastewater from pesticide and related industries.

Table 6-1 presents a list of the unit operations commonly used to treat pesticide industry wastewaters. However, this list does not include all the applicable treatment unit operations for the many varied waste streams in the pesticide formulating industry. An appropriate combination of unit operations can remove or destroy pesticides and other toxic pollutants to levels which allow reuse of the treated wastewater, discharge to publicly owned treatment works (POTW), or direct discharge to surface waters. Pollutants that are removed by selected unit operations are shown in Table 6-2.

The most effective combination of the unit operations to achieve the desired treatment depends on the volumetric flow rate, the type and concentration of contaminants, the wastewater pH and temperature, and the desired effluent quality. The treatment system design must provide for both the level and the variation of each of these parameters. For example, equalization of a waste stream of highly varied flow may precede an oil-water separator for primary treatment. The separator effluent may then flow to a biological secondary treatment system, then to an activated carbon adsorption system providing tertiary treatment of the biological system effluent, then to final discharge or water reuse.

Table 6-1. Unit Operations for Treatment of Pesticide Formulating Wastewaters

- Filtration
- Incineration
- Oil/water separation
- Flotation
- Evaporation
- Stabilization
- Equalization
- Decantation
- Precipitation
- Coagulation/flocculation
- Biological treatment
- Activated carbon adsorption
- Hydrolysis
- Chemical oxidation
- Resin adsorption
- Steam/air stripping

Source: ESE and TRW, 1983.

Table 6-2. Pollutant Groups Removed by Selected Treatment Unit Operations

Pollutant Groups	Activated Carbon	Resin Adsorption	Steam Stripping	Hydrolysis	Biological Oxidation	Chemical Oxidation
Volatile Aromatics			*		*	
Halomethanes			*		*	
Cyanides				*	*	*
Haloethers			*		*	
Phenols	*	*			*	
Nitro Substituted Aromatics			*		*	
Polynuclear Aromatics					*	
Chlorinated ethanes (ylenes)			*		*	
Nitrosamines	*				*	
Phthalates					*	
Dichloropropane (ene)			*		*	
Pesticides	*	*		*	*	*
Dienes	*	*			*	
TCDD	*					

Source: ESE, 1986.

The desired effluent quality depends on whether the wastewater be reused as process water in the plant, discharged to a POTW, or directly discharged to surface waters. The best choice may be to reuse some wastes, and to discharge the others. Therefore, the system design should consider segregation of the various waste streams by type and contaminant strength to allow specialized handling of each. This is because the use of specialized treatment/handling systems, one for each segregated waste type, is often more cost effective than a large process effluent treatment system for a single combined waste stream.

Appropriate combination of the unit operations listed in Table 6-1 can provide the waste management opportunities described above. A summary description of each treatment unit operation is presented below.

Activated Carbon Adsorption

Activated carbon adsorption is a physical separation process. Organic and inorganic materials are removed from wastewater by sorption onto the carbon surface. The typical process uses either a fixed or moving bed of granular carbon or a powdered carbon in a slurry. Design factors include:

1. Increasing molecular weight is conducive to better adsorption.
2. The degree of adsorption increases as adsorbate solubility decreases.
3. Aromatic compounds generally are more readily adsorbed than aliphatics.
4. Adsorption is pH dependent.

For granular activated carbon adsorption systems, fixed beds are commonly used for the treatment of pesticide wastewaters. The primary design and cost factor is the bed volume required for attaining the desired pollutant removal. Spent carbon must be regenerated or replaced depending on the carbon use rate. This is most heavily influenced by the wastewater characteristics. The decision to regenerate the spent carbon should be based on the spent carbon disposal cost versus the cost to thermally regenerate the carbon. Carbon regeneration is typically accomplished with a multiple-hearth furnace.

Biological Treatment

One common form of biological treatment for industrial wastewaters is the activated sludge process. In this process, wastewater is fed continuously into an aerated tank. There biological microorganisms metabolize and biologically flocculate the organic contaminants. The microorganisms, or activated sludge, are settled from the aerated mixed liquor under quiescent conditions in a final settling tank, or clarifier. A portion of the settled activated sludge is returned to the aeration tank. The clear supernate from the clarifier is the plant effluent. The key aspect of the activated sludge process is that it recycles active biological sludge solids back to the aeration tank. The principal design factors are the wastewater flow, waste characteristics, and detention time in the aeration basin. The detention time is calculated based on the influent concentrations of pollutants, the resulting biochemical oxygen demand from the microorganisms, and other parameters relating to the concentration of microorganisms and the food to microorganism ratio. Another important design consideration is adequate aeration to meet the biochemical oxygen demand and thereby support the aerobic biological treatment process. Design factors influencing the design of an aeration system include aeration basin volume, oxygen transfer requirements, and mixing requirements.

Gravity sedimentation is the process utilized in the final clarifier for settling the suspended activated sludge biomass from the aeration tank wastewater. The principal design factors are influent flow, the clarifier overflow rate, the influent suspended solids concentration, and the settleability of the suspended solids.

Incineration

Incineration is an applicable technology for the treatment of concentrated organic process wastes. This includes concentrated reject streams generated by other unit operations such as biological treatment system sludge. For biological sludges, multiple-hearth furnace incineration is applicable. A vertical liquid injection incinerator is generally more applicable for liquid process wastes. In a multiple-hearth furnace, the waste descends through several grates to be burned in increasingly hotter combustion zones. In a liquid injection incinerator, the waste stream is atomized with high pressure air or steam and burned in suspension.

The high temperature oxidation in an incinerator degrades the waste into carbon dioxide, steam, sulfur dioxide, nitrogen oxide, hydrogen chloride gases, and ash. Harmful components are particulates, sulfur dioxide, nitrogen oxide, hydrogen chloride, and products of incomplete combustion. These require air pollution control equipment to control the release of contaminants into the atmosphere. Important design parameters include the combustion zone temperature, the waste volume flow rate, the residence time at the combustion temperature, and combustion chamber mixing.

Hydrolysis

Hydrolysis is a chemical reaction between water and another substance which chemically alters the substance. In the hydrolysis of pesticide-contaminated wastewaters, a catalyst, or hydrolyzing agent is often used. These include acids, alkalines, and enzymes. Most pesticides will react in alkaline media. Reaction rates and conditions are very specific to each pesticide, with pH and temperature generally having the greatest influence. A critical factor in hydrolysis treatment design is the possible generation of products more toxic than the original pesticide. For example, the hydrolysis of parathion will generate the more toxic p-nitrophenol.

Chemical Oxidation

Chemical oxidation processes are used to chemically break down pollutants such as cyanides, sulfides, and formaldehydes. These are not amenable to biological or other traditional means of treatment. Powerful oxidants such as chlorine, peroxide, or permanganates are used for chemical oxidation. Which oxidant to use depends on the specific pollutant to be treated and concern over the generation of more toxic chlorinated compounds. Cyanide treatment by an alkaline chlorination process is now widely used and can achieve nearly complete cyanide destruction. In the alkaline chlorination process, chlorine is added to the wastewater at a mass ratio of about 15 parts chlorine to 1 part cyanide. Caustic is added to control pH between 8.0 and 9.5 which subsequently neutralizes any excess chlorine. The principal design factors are the wastewater flow rate and cyanide concentration. Reaction vessels are commonly sized for a 10-minute residence time for the chlorination stage, and a 30-minute residence time for the caustic addition stage.

As previously mentioned, toxic chlorinated organics may result from alkaline chlorination of cyanide.

Chemical oxidation using hydrogen peroxide and ozone has proved effective for the treatment of waste streams containing several organic compounds. These can include organic sulfur compounds, phenols, chlorinated hydrocarbons, pesticides, and nitroso compounds. The pesticides include DDT, dieldrin, malathion, methylparathion, and aldrin.

Resin Adsorption

A synthetic polymeric resin can be used effectively to remove and recover specific compounds from the wastewater. Capacity of the resin is dependent on the following wastewater characteristics:

- Type and concentration of the specific organics;
- pH;
- Temperature;
- Viscosity;
- Polarity;
- Surface tension; and
- Background concentrations of other organics and salts.

Because the binding energies of the polymers are normally lower than those of activated carbon, solvent and chemical regeneration and recovery is generally possible. Regeneration can be performed with caustic, formaldehyde, or with other solvents.

Resin adsorption systems typically consist of one or more flow-through columns which contain the resin. Multiple columns are usually operated alternatively to allow regeneration of one column while the other is operating. In a single column system, a raw wastewater storage tank is utilized while column regeneration is performed. Resin adsorption has been demonstrated for effective removal of phenols, some chlorinated hydrocarbons, and endrin.

Steam/Air Stripping

Stripping is used to remove volatile contaminants from wastewater using either air or steam as the stripping agent. This process is usually designed for a single limiting contaminant. The wastewater and the steam or air are contacted continuously in a fractionating column. The column can be a countercurrent packed tower, or use bubble cap or sieve tray stages. The more important design factors include the contaminant solubility in water, distribution coefficients for the packed tower media, vapor pressure, and heat of vaporization. The concentration of contaminants in the air emissions and the need for air pollution control equipment must also be considered.

CHAPTER 7.0

ECONOMICS OF WASTE REDUCTION TECHNIQUES

The costs of implementing various waste reduction options may initially be high. However, the savings in disposal costs for hazardous wastes may recover the initial costs in an economical time period. This payback period will improve as the hazardous waste disposal costs continue to increase. Furthermore, as more types of hazardous waste are banned from landfill disposal, the incentive for waste reduction or complete elimination will become even greater.

The economics of implementing various source control, recycling, and treatment techniques to effect waste reduction are discussed here.

7.1 SOURCE REDUCTION

As discussed in Chapter 4.0, there are several source reduction techniques applicable to the pesticide formulating industry. These include improved operating practices, good housekeeping, and process modifications to reduce or eliminate the generation of hazardous waste. New or revised operating practices generally have the least immediate cost because they typically do not require costly capital improvements to plant equipment. However, such a revision in operating procedures may reduce plant efficiency during implementation. The revised procedure may also increase labor and other costs. Therefore, a comprehensive economic analysis of capital expenditures, operating costs, and reduction in waste disposal cost should be prepared for all the waste management options available. As an example, one plant may consider the use of a more detailed recordkeeping system for the type and quantities of used rinsing/flushing media generated. This could be used to optimize media reuse for additional rinsing/flushing or as a diluent in subsequent pesticide formulations. The cost components of this system would include:

- The design and printing of recordkeeping forms;
- The training of plant personnel in the use of the new record-keeping system and the waste reduction goals of the new system;
- The additional operator labor required to enter the information on the new forms;
- The additional management labor required to review and evaluate the new records; and
- The possible requirement of constructing additional storage space for used rinsing/flushing media.

The economic feasibility would depend on whether the savings in waste disposal cost could recover the cost of implementing the new record-keeping system within an economical time period. The degree of uncertainty in estimating the waste volume reduction and associated long term disposal cost savings must also be considered. A trial implementation of the new system would reduce the uncertainties.

Process modifications are usually more costly than operating procedure revisions unless the modification is minor. An example of a minor modification is the installation of spray nozzles on floor washing hoses to increase washing efficiency and minimize wastewater generation. An example of a costly modification is the installation of an enclosed automatic cut-in hopper for bags of pesticide dust to collect fugitive dust emissions for reuse. A typical cost of the latter is about $15,000. Even with this relatively high capital cost, if this pesticide dust formulating mill is used regularly the savings resulting from the reuse of the collected dust emissions may recover the initial cost within an economical payback time.

7.2 RECYCLING AND RESOURCE RECOVERY

As described in Chapter 5.0, recycling and resource recovery techniques may involve some form of waste treatment. This occurs when the treated material is reused as a raw material or recovered as a usable product. Pesticide formulating wastewater can be treated for use/reuse as process water rather than disposing of the wastewater as a hazardous waste. This can reduce disposal costs and be an economically attractive recycling technique. Also, floor wash water or stormwater runoff from process areas can be collected and treated for use/reuse as floor wash water or equipment rinse water. This may prove to be less costly than disposing of these waste streams as a hazardous waste. Factors to be considered in evaluating such a recycle option are listed below:

1. Quantity and quality of raw wastewater.
2. Quantity and quality of water required for intended application.
3. Cost of constructing and operating wastewater collection/treatment system.
4. Cost of disposing of the wastewater as a hazardous waste.

Another important option is the segregation of the various process waste streams as discussed in Chapter 5.0. This can improve recyclability and reduce wastewater treatment costs. This would allow use of specialized handling or treatment systems, one for each of the different individual waste streams. This option is often more cost effective than utilizing a large complex treatment system for the combined waste stream. Segregation of the waste streams should be based on an evaluation of the flow rates and characteristics of each waste stream to identify low strength versus high strength wastes, and waste streams of similar characteristics that could be routed to the same treatment equipment.

7.3 WASTEWATER TREATMENT

As a waste reduction measure, wastewater treatment reduces the toxicity of the wastewater. The water may then be recycled, or it can be discharged to a POTW or surface waters. In evaluating these options, a cost estimate for constructing, operating, and maintaining an appropriate wastewater treatment system must be made. The type of treatment required depends on the flow rate and characteristics of the waste stream, the desired effluent quality, and other technical and economic parameters. The resulting treatment system design includes the number and size of treatment vessels; anticipated treatment chemical doses or usage rates; energy requirements for treatment equipment, pumps, mixers, and aerators; operation and maintenance labor; and other operation and maintenance costs. Much treatment system cost information is available in technical literature, from equipment suppliers, and from reference handbooks. An overall cost estimate for the particular waste reduction option can then be prepared.

The treatment of pesticide-contaminated wastewaters as part of a recycling option is generally much more costly than source control techniques. Capital costs of treatment systems are commonly in excess of $100,000 and often approach or exceed $1,000,000 for higher wastewater flows. Therefore, cost estimates should be prepared for each of the waste management options. The options should then be compared with each other and evaluated in light of the company's long term strategy. The appropriate waste management decision will then be an optimum economic decision.

CHAPTER 8.0

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CHAPTER 9.0

ACRONYMS AND ABBREVIATIONS

APCD	Air Pollution Control District
AQMD	Air Quality Management District
BA	Bay Area
BTU	British Thermal Unit
CAC	California Administrative Code
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHSC	California Health and Safety Code
DHS	Department of Health Services
EPA	Environmental Protection Agency
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
Gal	Gallon
HSWA	Hazardous and Solid Waste Amendments
KC	Kern County
Kg	Kilogram
Lb	Pound
Mg	Milligram
NPDES	National Pollution Discharge Elimination System
POTW	Publicly Owned Treatment Works
RCRA	Resource Conservation and Recovery Act
SB	Santa Barbara
SC	South Coast
SLOC	San Luis Obispo County
TSD	Treatment, Storage, and Disposal
USC	United States Congress
VOC	Volatile Organic Chemicals

APPENDIX A

HAZARDOUS WASTE MINIMIZATION AUDIT REPORT FOR PLANT A

A.1.0 INTRODUCTION

Plant A was audited by an engineer of Environmental Science & Engineering, Inc. (ESE) on September 24, 1986. The audit consisted of a review and copying of plant records, a plant inspection tour and an interview with the Plant Manager. During the audit, sources of hazardous waste generation were identified, and methods of hazardous waste handling and disposal were reviewed. In addition, existing waste minimization techniques were evaluated.

A.2.0 PLANT DESCRIPTION

Plant A mainly formulates granule and dust fertilizers, but also formulates three herbicide/fertilizer mixtures in granule/dust form. These mixtures are commonly referred to as weed and feed products. The three herbicides used in formulating these three products are:

1. Liquid Trimec
2. Trimec dust, and
3. Dimethyl - T dust.

The liquid Trimec is injected into a vermiculite/granule fertilizer mixture, and the Trimec and Dimethyl-T dusts are mixed with various formulations of granule and dust fertilizers. The weed and feed formulation is performed in one mixer which has a capacity equivalent to 500 pounds (lb) of product. The granule/dust fertilizer and herbicide dust are loaded into the top of the mixer through a port, and the mixer is equipped with an internal mixing bar which rotates to provide the required mixing action. The mixing bar is constructed of steel pipe, and is also used to convey liquid Trimec through ports in the mixing bar into the fertilizer contained in the mixing tank. Mixing procedures for each weed and feed formulation are described in the following sections.

A.2.1 LIQUID TRIMEC

Liquid Trimec is received at the plant as a raw material in 55-gallon (gal) steel drums. During formulations with the liquid Trimec, a drum of the Trimec is placed adjacent to the mixing tank. After the granule/dust fertilizer has been loaded into the mixer, the Trimec is pumped from the drum into the tank through the mixing bar. For each 500 lb batch of weed and feed product, 2 quarts of liquid Trimec are added and mixing is performed for 15 minutes.

After mixing, the product is transferred through a hopper in the bottom of the mixing tank into a transfer box located underneath the mixing tank. The transfer box is then transported by a forklift to the packaging hopper where the product is loaded into the hopper. The product is then gravity fed from the hopper into 16-lb paper bags for storage in an onsite warehouse and ultimate distribution.

On an average annual basis, two to three drums of the liquid Trimec are used in weed and feed formulation.

A.2.2 TRIMEC DUST

The Trimec dust is received at the plant in 24-lb paper bags as a raw material. In formulating Trimec dust products, one 24-lb bag of the Trimec dust is added for each 500-lb batch of weed and feed product. The Trimec dust is added to the mixer through the same top loading port that is used to load the fertilizer into the mixer. Following a 15-minute mixing time, the product is transferred to the packaging hopper and packaged the same as the liquid Trimec formulations.On an average annual basis, approximately 7,200 lb of Trimec dust are used in weed and feed formulations.

A.2.3 DIMETHYL - T DUST

The Dimethyl-T dust is received at the plant in 24-lb plasticlined cardboard cartons as a raw material. Six lb of the Dimethyl-T dust are weighed out on a scale located adjacent to the mixing tank, and added to the fertilizer in the tank through the top loading port. Mixing of the Dimethyl-T dust and the fertilizer is performed for 20 minutes. Transfer of the formulated product from the mixer and packaging of the Dimethyl-T products is the same as that for the Trimec dust products.

On an average annual basis, approximately 1,800 lb of Dimethyl-T dust are used in weed and feed formulations.

A.3.0 WASTE GENERATION, HANDLING, AND DISPOSAL

There are four sources of hazardous waste generation at Plant A.

1. Dust collected from the product transfer and packaging areas;
2. Empty dust product bags and cartons;
3. Empty drums of liquid Trimec; and
4. Wastewater generated by the annual steam cleaning of the mixing tank.

Information relative to the generation, handling, and disposal of each of these wastes is described in the following sections.

A.3.1 VACUUM SYSTEM DUST

A vacuum system, which is dedicated to the herbicide mixing line, collects dust generated in two areas of this mixing line. The first area is above the transfer box which is used to transport the formulated product from the mixing tank to the packaging hopper. When the formulated product is released from the mixing tank through the hopper into the transfer box, dust is generated as the product falls into the transfer box. A flexible vacuum hose connected to the vacuum system in manually held over the tansfer box to collect the dust generated during product transfer.

The second dust collection area is located at the bottom of the packaging hopper. In this area, two vacuum system intake lines are mounted along the side of the bottom of the packaging hopper just above the packaging conveyor belt. These intake lines collect dust generated as product is released from the packaging hopper into bags on the conveyor belt.

The dust collected from above the transfer box and underneath the packaging hopper is directed to a 55-gal collection drum located outside of the building in a totally enclosed steel housing. This dust is reused in subsequent formulations of weed and feed product. The quantity of dust that is collected on an average annual basis is roughly 10 drums. This dust quantity is only a rough estimate because the vacuum system has been in place for less than a year, and a long term database of dust quantity data does not exist to allow a more accurate estimate.

A.3.2 EMPTY DUST PRODUCT CONTAINERS

The empty paper bags and cartons of the Trimec dust and Dimethyl-T dust are collected in a steel 55-gal drum. The containers are manually compacted in the drums to optimize the number of bags per drum. An average of approximately five drums of empty product bags are generated annually, and the drums are hauled by a licensed hazardous waste transporter to an approved offsite hazardous waste disposal facility.

A.3.3 EMPTY DRUMS

When a drum of liquid Trimec is totally consumed in the formulating process, the empty drum is used to collect emptydust product containers as described in Section A.3.2.

A.3.4 WASTEWATER

Wastewater is generated by the periodic steam cleaning of the mixing tank and internal mixing rod with a portable steam jenny. This cleaning operation, which is usually performed once per year, generates approximately 20 gal of wastewater.

This wastewater is collected in a dedicated 55-gal drum and injected into subsequent product formulations of Dimethyl-T dust product.

A.4.0 AUDIT FINDINGS AND RECOMMENDATIONS

The current methods of waste management at the Plant A are successful in minimizing the quantity of hazardous waste requiring disposal. As described earlier, the dust collected in the vacuum system and the wastewater generated by steam cleaning of the mixing tank are reused in subsequent product formulations. Because of the additional operational requirement to collect and inject the wastewater into product formulations at a controlled rate, minimization of the volume of wastewater generated is an inherent component of the waste management process.

The only hazardous waste that requires disposal are the drums of compacted empty product containers. As described earlier, the product containers are manually compacted in the drums. It is recommended that consideration be given to mechanical compaction to reduce the number of drums for disposal. A reduction from the annual average of five drums to four drums is conceivable if mechanical compaction were utilized. A compaction device for use by a forklift could be manufactured for a cost of about $300. At present, Plant A incurs a cost of $70 per drum for transportation and disposal at an approved hazardous waste disposal facility. Therefore, the period of return on the investment on the mechanical compaction device would be between 4 and 5 years.

In addition to the recommendation presented above, a general recommendation to improve the plant's environmental management of the herbicide mixing operation was also developed. At present,the flooring in the herbicide mixing area consists of compacted native soil. Any fugitive dust from the formulation process that has deposited on the ground is subject to migration outside the building on the tires of the forklift and on employees shoes. The paving of this area would allow collection of the dust with the vacuum system for reuse in subsequent product formulations, and minimize the amount of dust migration outside of the building. The paving of this area would cost approximately $2,000.

APPENDIX B

HAZARDOUS WASTE MINIMIZATION AUDIT REPORT FOR PLANT B

B.1.0 INTRODUCTION

Plant B was audited by an engineer of Environmental Science & Engineering, Inc. (ESE) on September 24, 1986. The audit consisted of a plant inspection tour and an interview with the Plant Manager. During the audit, sources of hazardous waste handling and disposal were reviewed.

B.2.0 PLANT DESCRIPTION

Plant B is mainly engaged in the formulation and distribution of fertilizer, but also formulates a small quantity of liquid pesticides. The pesticides formulated are primarily insecticides consisting of malathion and diazinon in a xylene carrier solution. The mixing of the active ingredients with the xylene is performed in a 40-gallon (gal) stainless steel mixing tank equipped with a portable mixing propeller. The active ingredients and the xylene are received at the plant in 55-gal drums, and are added to the mixing tank by using a pump. Following mixing, the mixing tank is raised by a forklift, and the formulated product is drained through a spigot on the side of the tank into a 55-gal drum. The drum is then transported to the packaging area where the pesticide is pumped into 8-ounce bottles for distribution.

On an average annual basis, approximately 400 gallons of pesticide is formulated.

B.3.0 WASTE GENERATION, HANDLING, AND DISPOSAL

The only source of hazardous waste generation at Plant B relating to the pesticide formulating operation are rags used to wipe down the 40-gal mixing tank and small spills following formulation of each batch. An estimated 10 to 20 pounds (lbs) of pesticide contaminated rags are generated annually. The rags are disposed of in the dumpster and ultimately in a sanitary landfill.

B.4.0 AUDIT FINDINGS AND RECOMMENDATIONS

The pesticide-contaminated rags generated by cleaning the mixing tank and small infrequent spills are possibly classified as a hazardous waste, depending primarily on the quantity of pesticide in the rags. Sampling and analysis of the rags to determine the content of pesticide and carrier solvent in the rags would be required to determine if their content exceeds the hazardous waste criteria set forth in Article 11, Title 22, California Administrative Code.

If the rags are determined to be a classified hazardous waste, they should not be disposed of in a sanitary landfill. One alternative is to collect the rags in a 55-gal drum for ultimate disposal at an approved hazardous waste disposal facility. If the rags are not accumulated longer than 90 days prior to disposal, then a hazardous waste storage facility permit will not be required. However, the drum must be stored and transported in accordance with the requirements for generators of hazardous waste (Article 6, Title 22, California Administrative Code). If Plant B generates less than 100 kilograms (kg) during any calendar month, the 90-day accumulation time limit identified above would begin when the amount of pesticide-contaminated rags reached 100 kg. At a maximum generation rate of approximately 20 lbs or 9 kg of rags per year, the rags could be accumulated up to 11 years before the small quantity exclusion limit of 100 kg would be exceeded. Assuming that up to 220 lb of contaminated rags could be placed in a 55-gal drum, only one drum would be required to store the rags over the 11-year period. However, because of the future landfill disposal ban of hazardous wastes and the potential risk associated with possible spontaneous combustion of the rags due to solvent carrier solution content, disposal of the rags on a more frequent basis would be prudent. Additionally, the above 100 kg limitation is reduced to 1 kg for waste classified as extremely hazardous. The current disposal cost for one drum is approximately $70.

As the costs for hazardous waste disposal increase, an alternative method of cleaning the pesticide mixing tank that generates a reusable product may be considered. An example of such an alternative is the use of a small pressure washer to apply carrier solution and a squeegee to clean the tank, with collection of the resulting spent solution for reuse in subsequent formulations. This alternative also includes the placement of a shallow stainless steel pan underneath the mixing tank to catch any small spills which may occur during formulation or transfer operations. The pan should be slightly elevated and equipped with a spigot, so spills could be collected for reuse in pesticide formulation.

The capital and additional operating costs to implement this alternative are estimated to be approximately $200 and $150 per year, respectively.

These costs estimates are based on the following assumptions:

- Capital cost of catchment pan and portable pressure washer = $200.

- Additional operational requirement of 10 labor hours per year for tank cleaning.

- Labor rate of $15 per hour.

APPENDIX C

HAZARDOUS WASTE MINIMIZATION AUDIT REPORT FOR PLANT C

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CHAPTER C.1.0
INTRODUCTION

Plant C was audited by a team of two engineers from Environmental Science and Engineering, Inc., (ESE) on September 3 and 4, 1986, and the information presented in this report is current as of September 1986. The 2-day effort included review and copying of records, plant inspection tours, and interviews with plant personnel.

Special attention was given to the plant's hazardous waste generation sources; handling, treatment, and disposal methods; and existing and proposed hazardous waste minimization techniques. Waste minimization techniques potentially applicable to the plant, and to pesticide formulators and repackagers in general, were identified. The potential economic benefits of the hazardous waste minimization techniques were identified.

CHAPTER C.2.0
PLANT DESCRIPTION

This chapter discusses the plant setting, processes, and support operations used to formulate up to 600 different pesticide formulations in liquid, dust, and granular form.

C.2.1 GENERAL SITE CHARACTERISTICS

The plant consists of two areas, a 12.5-acre developed area encompassing the production and office areas, and a 5-acre undeveloped tract. In 1930, the plant was constructed primarily for sulfur grinding. The operations at that time consisted of a single Raymond mill. Since then, the plant has grown to include two Raymond mills, five dust mills, three granular mills, and a variety of liquid pesticide formulation operations.

In 1980, the plant was renovated, including an addition of process equipment from a closed plant, new buildings to house equipment, and paving of much of the remaining undeveloped production area.

The production area currently consists of 16 large buildings, a percolation pond, several bulk product and waste storage areas, and pallet and drum storage areas. The balance of the production area is open pavement.

In the developed area of the plant, stormwater runoff from the office and parking lot areas, which total approximately 2 acres, drains to the percolation pond. Runoff from the process and storage areas, which total approximately 10.5 acres, drains to centrally located sumps for collection and storage as hazardous waste. Stormwater runoff from the 5-acre undeveloped area of the plant is contained onsite in the natural drainage system.

C.2.2 RAW MATERIALS AND PRODUCTS

Because the plant is a pesticide formulator and repackager, raw materials are limited to bulk technical-grade pesticides, diluents, various additives, and sulfur. Technical-grade pesticides include concentrated or pure pesticides in liquid, powder, and granular forms. Diluents include water, solvents, oils, sands, and clays.

Some bulk pesticides are shipped to the plant for repackaging into smaller containers. Dust mill 2A and the paraquat packaging mill are examples of dedicated repackaging process areas. Technical-grade materials are typically received by truck. The materials are distributed for processing, which involves mixing with diluents and packaging as finished product.

The plant can currently formulate over 600 different registered formulations. In 1986, the plant produced 2.1 million gallons of liquid pesticides and more than 40 million pounds of dry pesticides.

Approximately 60 percent of production results from contracts for custom and specialty formulations for outside clients. The remaining 40 percent of products produced includes a full line of proprietary insecticides, herbicides, fungicides, and rodenticides.

C.2.3 PROCESS DESCRIPTIONS

The plant consists of four main process areas: the sulfur, dust, granular, and liquids areas. Finished product is stored in the main warehouse for eventual distribution.

C.2.3.1 Sulfur Formulation Process

The sulfur process is the largest volume dry material, continuous production process area at the plant. In 1986, the sulfur process produced 22.5 million pounds of finished product.

The sulfur process begins with the unloading of bulk crude sulfur from trucks into a belowground hopper. A screw conveyor moves material on an elevator system to one of six large sulfur storage silos. Upon demand, crude sulfur is moved by screw conveyor to a small ribbon mixer. The mixer is used for the addition of resins and magnesium conditioners to prevent static charges. After mixing, the crude sulfur is conveyed to a holding bin in the mill building. As detailed in Figures C.2-1 and C.2-2, the sulfur is then milled in one of two Raymond mills and cycloned to another holding bin before being conveyed to a bagging machine.

Dust from the milling process is drawn off the cyclone system and collected for eventual recycle. Natural-gas-fired boilers generate carbon dioxide for inert gas blanketing of the milling process to reduce the chance of fire. Continuous monitoring systems monitor and record oxygen content throughout the process equipment and buildings.

A secondary operation in the sulfur process area is the sulfur x-mill. Figure C.2-3 presents a schematic diagram of the sulfur x-mill. The x-mill blends sulfur and bentonite under heat to form an insoluble sulfur product. Sulfur from the Raymond mills is blended with bentonite from a cut-in hopper. The material is elevated to a holding bin and then conveyed through a series of sterilizers. After sterilization, the material is crushed, passed through shaker screens and packaged in bags.

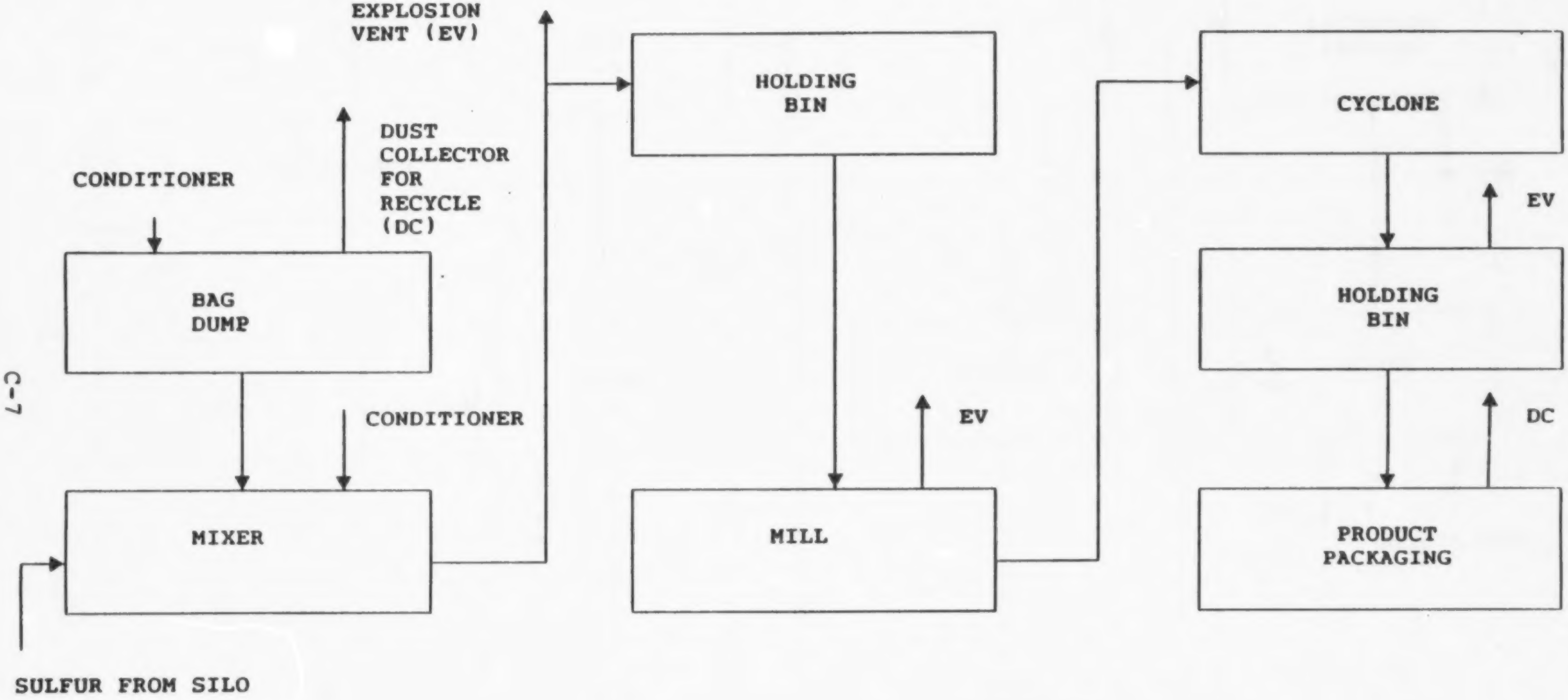
EXPLOSION VENT (EV)
DUST COLLECTOR FOR RECYCLE (DC)
CONDITIONER
BAG DUMP
CONDITIONER
MIXER
SULFUR FROM SILO
HOLDING BIN
MILL
EV
CYCLONE
EV
HOLDING BIN
DC
PRODUCT PACKAGING

FIGURE C.2-1 FLOW DIAGRAM FOR RAYMOND MILL-1

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AND ENGINEERING, INC.

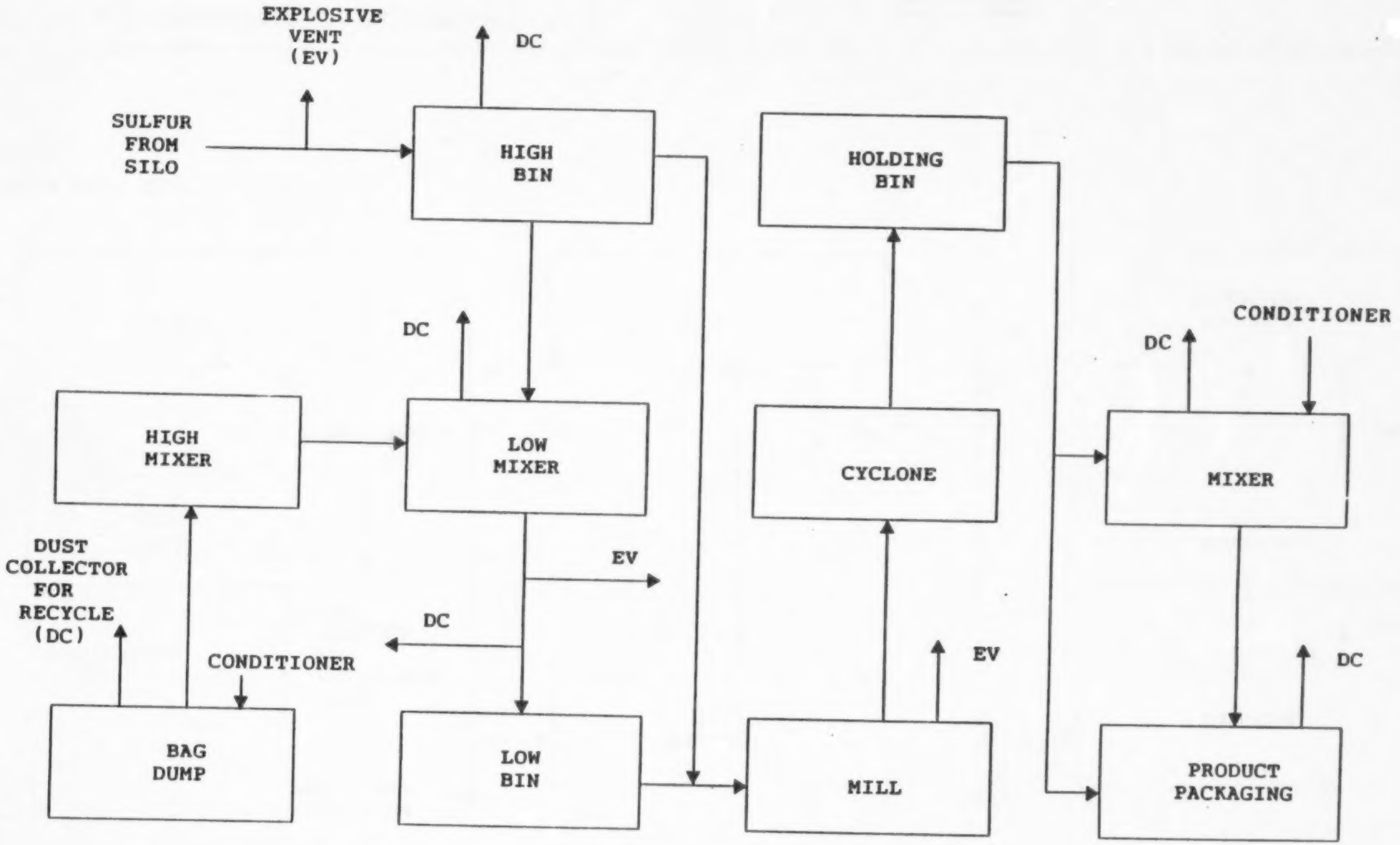
EXPLOSIVE VENT (EV)
DC
SULFUR FROM SILO
HIGH BIN
HOLDING BIN
DC
CONDITIONER
DC
HIGH MIXER
LOW MIXER
CYCLONE
MIXER
DUST COLLECTOR FOR RECYCLE (DC)
EV
DC
EV
DC
CONDITIONER
BAG DUMP
LOW BIN
MILL
PRODUCT PACKAGING

FIGURE C.2-2 FLOW DIAGRAM FOR RAYMOND MILL-2

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AND ENGINEERING, INC.

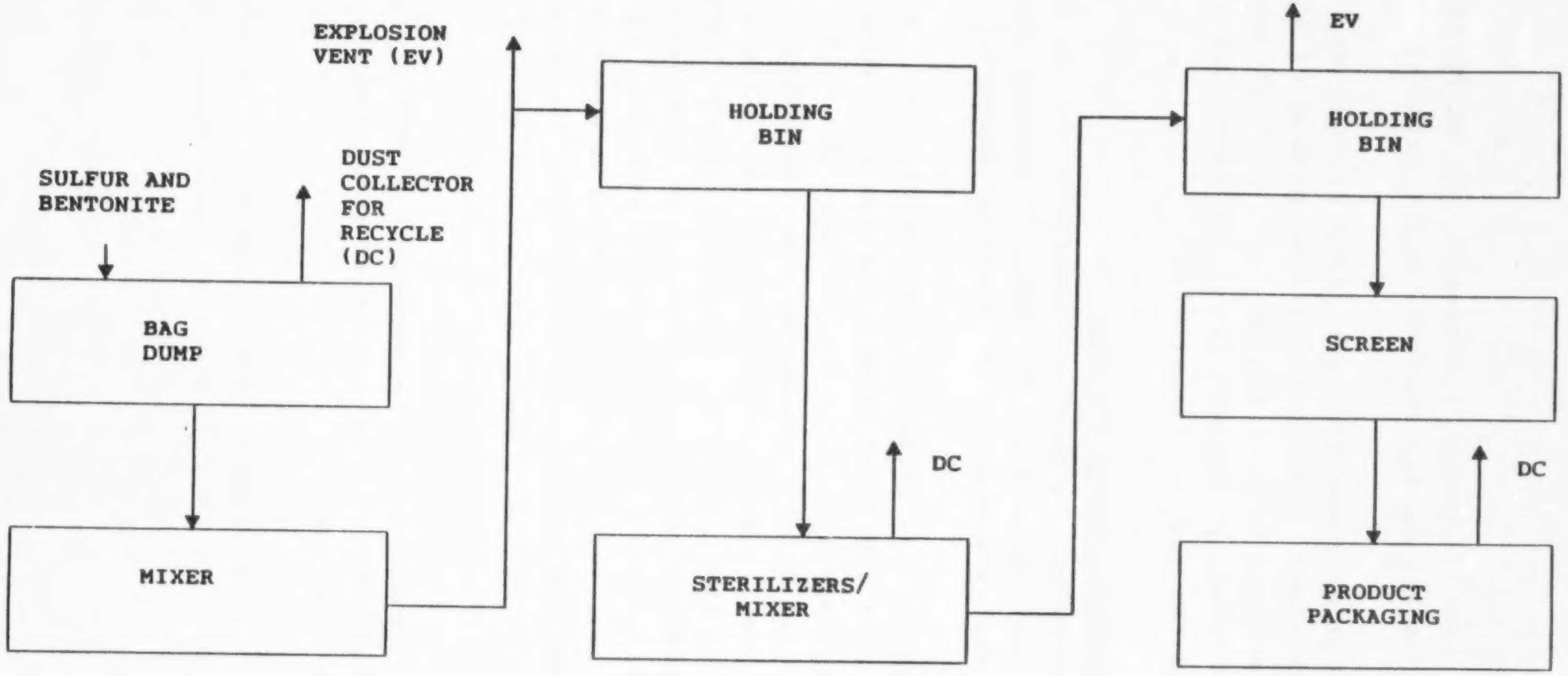
EXPLOSION VENT (EV)
SULFUR AND BENTONITE
DUST COLLECTOR FOR RECYCLE (DC)
BAG DUMP
MIXER
HOLDING BIN
STERILIZERS/ MIXER
DC
EV
HOLDING BIN
SCREEN
DC
PRODUCT PACKAGING

FIGURE C.2-3 FLOW DIAGRAM FOR SULFUR X-MILL

ESE
ENVIRONMENTAL SCIENCE
AND ENGINEERING, INC.

Both sulfur and x-mill product are bagged, placed on pallets, and shipped to a warehouse for eventual distribution.

The boiler and cooling tower are auxiliary operations in the sulfur area. Blowdown from both units is pumped to the bulk hazardous waste storage tank. Spilled or "wet" sulfur is a mixture of sulfur and condensate from the inert gas system. It is recycled to the head of the process.

C.2.3.2 Granular Formulation Process

By volume, the granular formulation operation is the second-largest process at the plant. In 1986, 11 million pounds of granular pesticides were produced as finished product.

The granular process area includes three mills, T-3, T-4, and T-5. Figures C.2-4 and C.2-5 detail the granular formulation process. Mill T-3 differs from mills T-4 and T-5 by the addition of a rotary dryer. Raw materials, including technical-grade pesticides and clay and/or sand diluents, are loaded into cut-in hoppers and elevated to holding bins. The materials are blended in rotary mixers while being inoculated with liquid pesticides. The granular material is formed during this mixing. After mixing, the materials are screened in a shaker screen and packaged in bags. Mill T-3 is equipped with a natural-gas-fired rotary dryer, positioned after the second holding bin.

Products from all three mills are packaged, placed on pallets which are covered with a plastic outer wrap, and shipped to the warehouse for storage.

At the completion of a product formulation run, the mills are flushed with diluent sand or clay to remove residual pesticide.

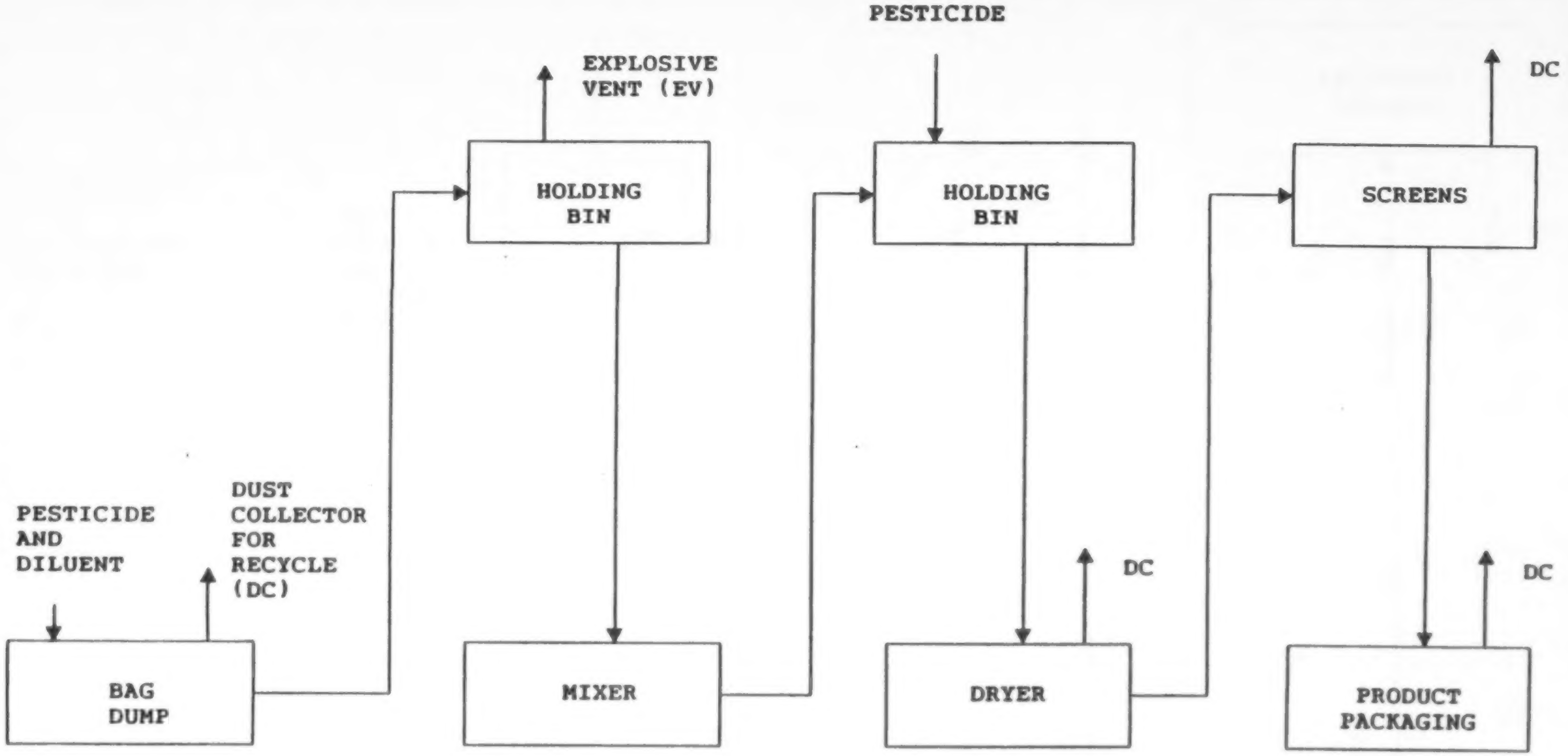
PESTICIDE
AND
DILUENT
DUST
COLLECTOR
FOR
RECYCLE
(DC)
BAG
DUMP
EXPLOSIVE
VENT (EV)
HOLDING
BIN
MIXER
PESTICIDE
HOLDING
BIN
DRYER
DC
SCREENS
DC
PRODUCT
PACKAGING
DC

FIGURE C.2-4 FLOW DIAGRAM FOR GRANULE MILL T-3

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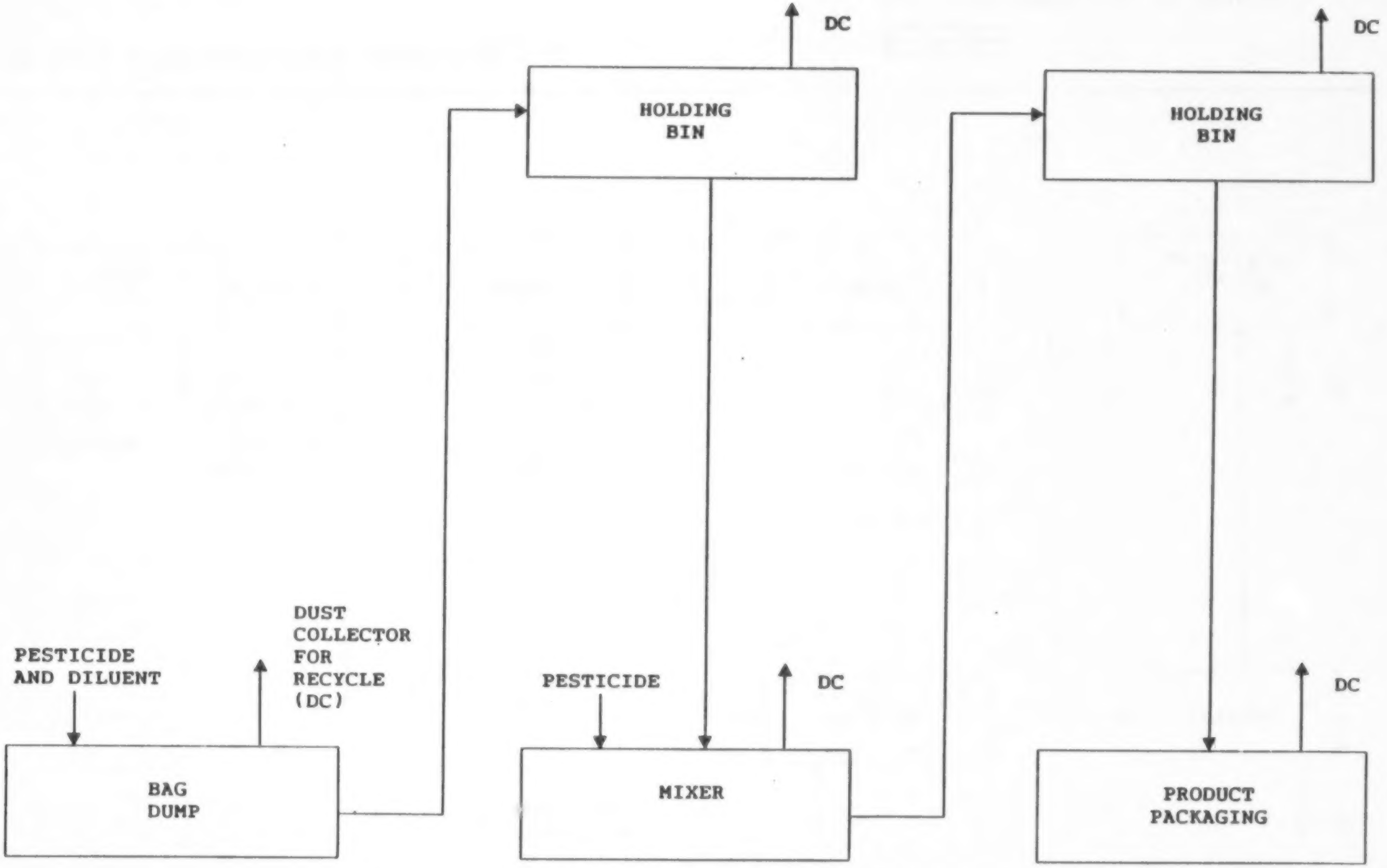
DC
HOLDING BIN
DC
HOLDING BIN
PESTICIDE AND DILUENT
DUST COLLECTOR FOR RECYCLE (DC)
BAG DUMP
PESTICIDE
DC
MIXER
DC
PRODUCT PACKAGING

FIGURE C.2-5 FLOW DIAGRAM FOR GRANULE MILL T-4

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All three granular mills have dedicated dust collectors. Dust is collected from the various mill components and recycled to the previous component. For example, dust drawn from the mixer is recycled to the cut-in hopper. In addition to the dedicated dust collection systems in the granular mills, a central vacuum system also serves the granular mill area, as well as the dust formulating area. The central vacuum system is used to collect product spills and general fugitive dust emissions that occur in both the granule and dust formulating buildings.

C.2.3.3 Dust Formulation Process

In 1985 the dust process formulated about 18 percent, or 7 million pounds, of the total dry product formulated at the plant.

The dust area uses five dust mills and one repackaging mill. Process flow diagrams for a dust mill and repackager are included as Figures C.2-6 through C.2-9. A typical dust mill begins with a cut-in hopper for loading dry technical material and diluent clays. These materials are conveyed to a holding bin before being loaded into a ribbon mixer. Liquid additives may be injected during mixing. After mixing, the materials are elevated to a second holding bin before being packaged in the bagging machine.

The repack mill shown in Figure C.2-10 involves only a cut-in hopper, elevator, holding bin, and bag machine. The repack mill does not blend materials. It is used only for repackaging products.

Product from all six mills is packaged, placed on pallets, and shipped to the warehouse for distribution.

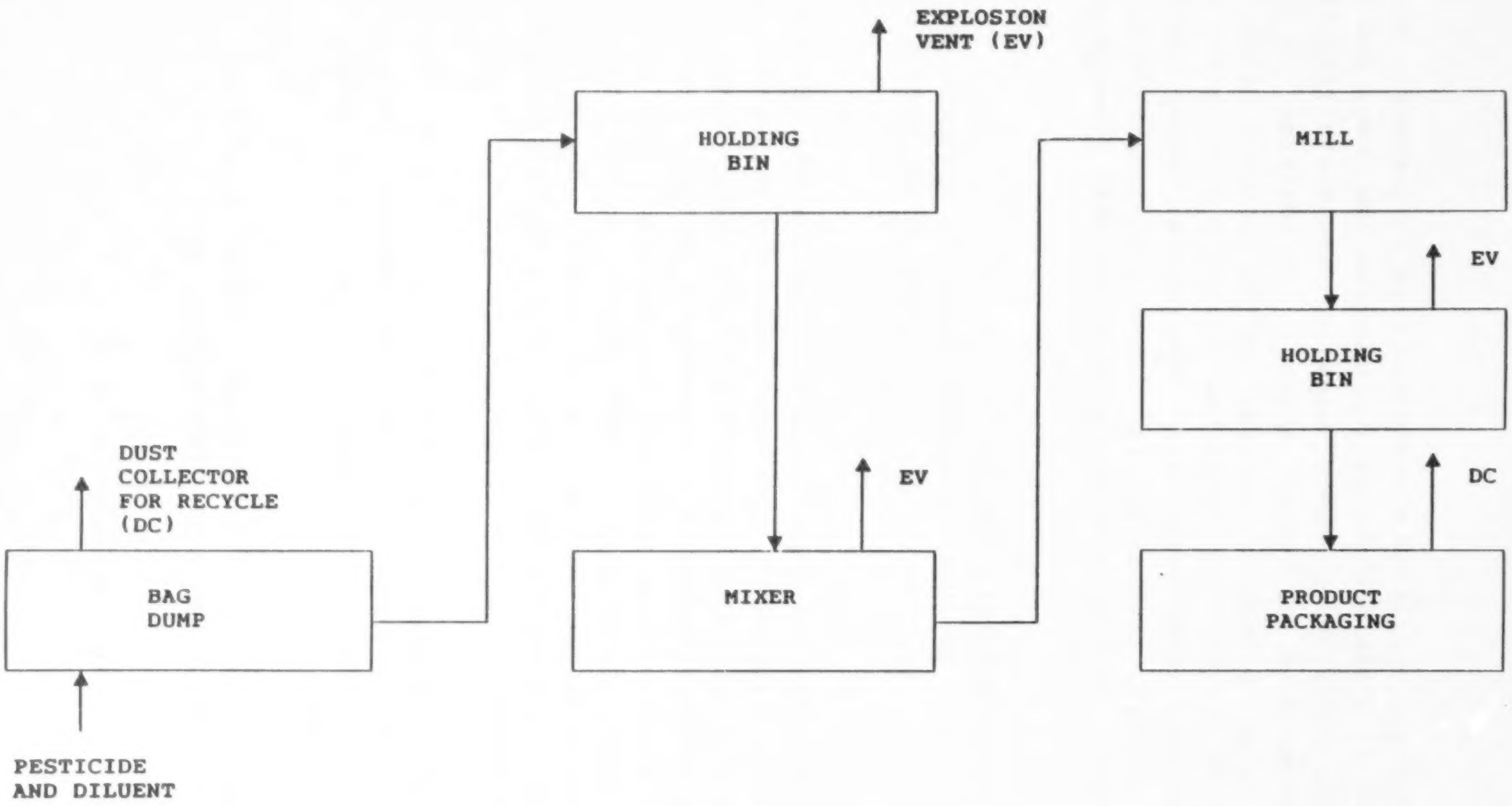
EXPLOSION VENT (EV)
HOLDING BIN
MILL
EV
HOLDING BIN
DUST COLLECTOR FOR RECYCLE (DC)
EV
DC
BAG DUMP
MIXER
PRODUCT PACKAGING
PESTICIDE AND DILUENT

FIGURE C.2-6 FLOW DIAGRAM FOR DUST MILL NOS. 1 AND 5

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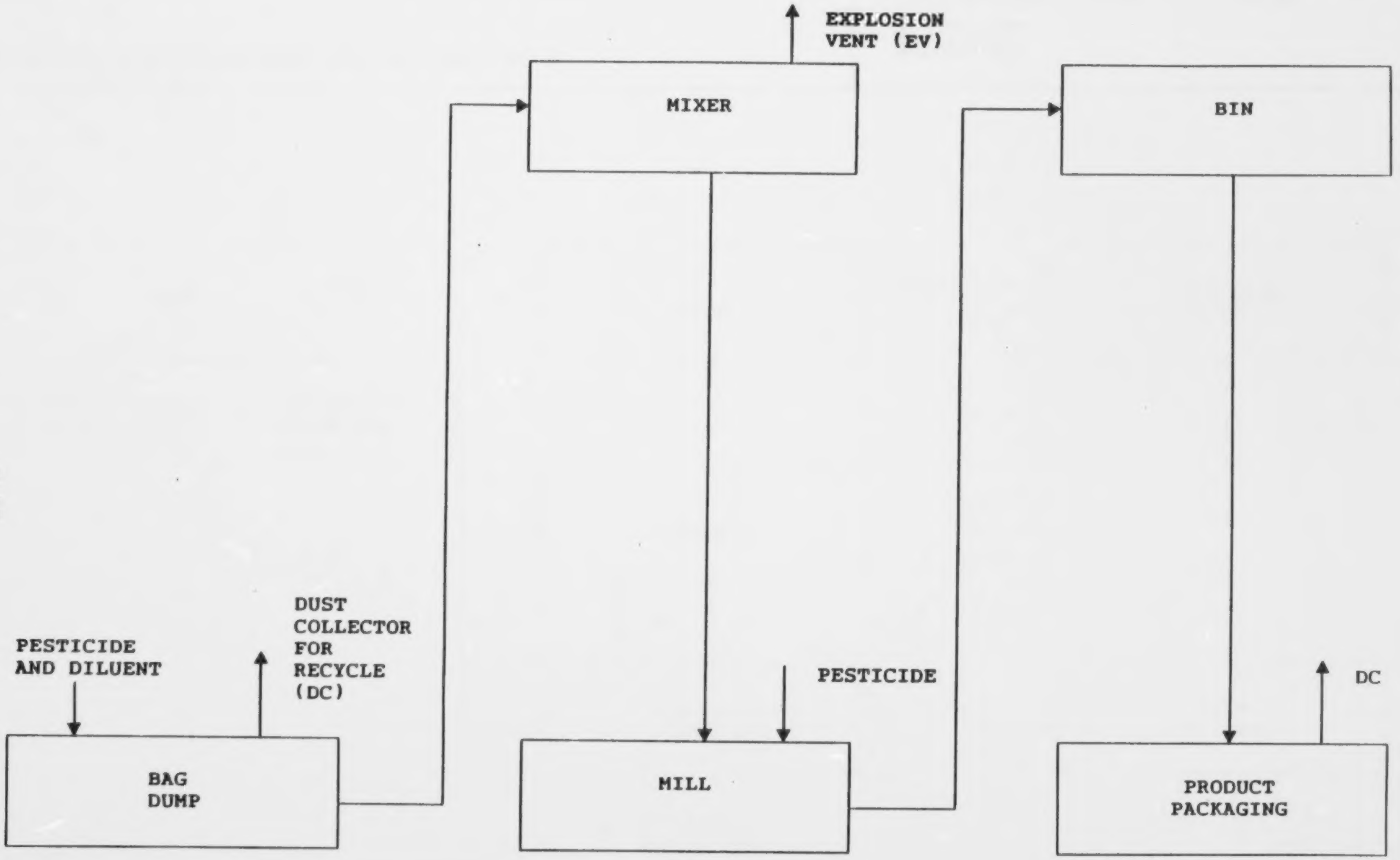
EXPLOSION VENT (EV)
MIXER
BIN
PESTICIDE AND DILUENT
DUST COLLECTOR FOR RECYCLE (DC)
PESTICIDE
DC
BAG DUMP
MILL
PRODUCT PACKAGING

FIGURE C.2-7 FLOW DIAGRAM FOR DUST MILL-NO. 2

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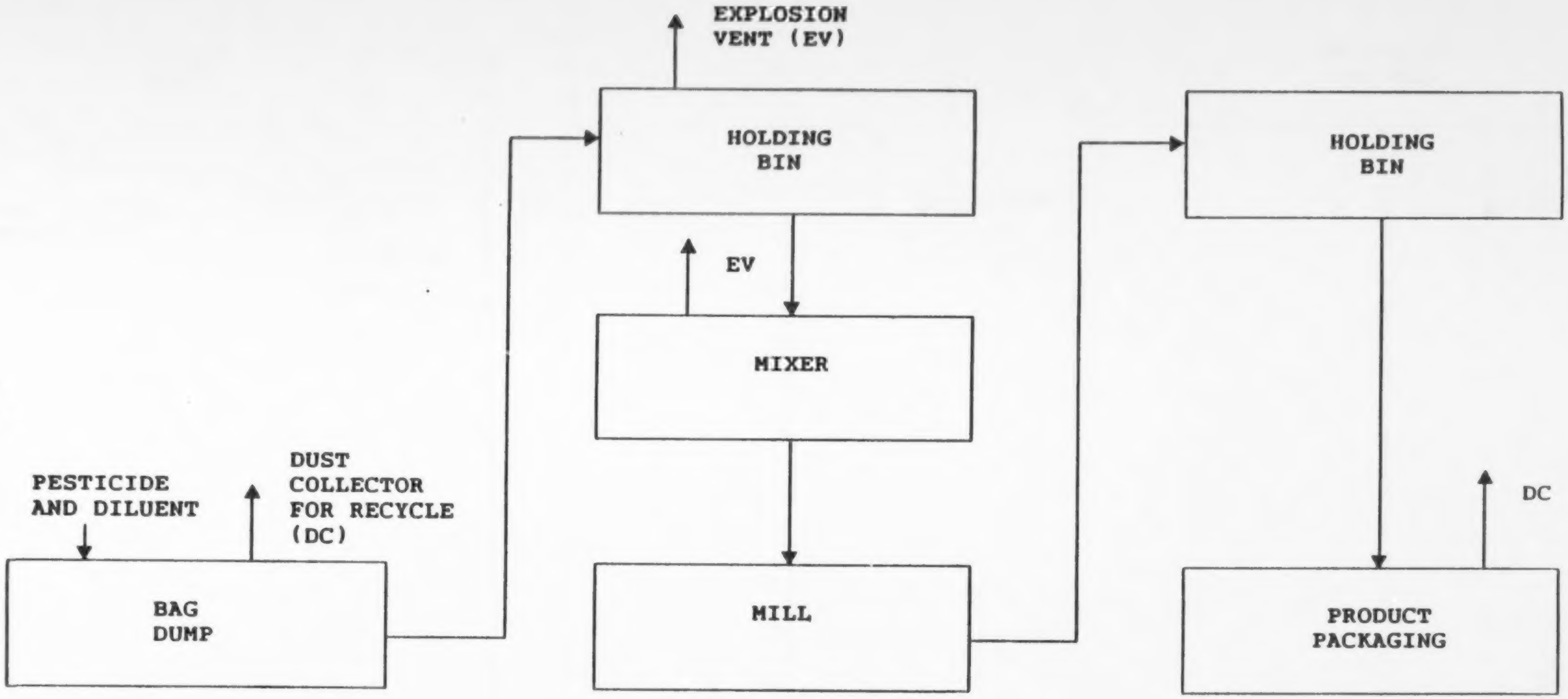
EXPLOSION
VENT (EV)
HOLDING
BIN
EV
MIXER
PESTICIDE
AND DILUENT
DUST
COLLECTOR
FOR RECYCLE
(DC)
BAG
DUMP
MILL
HOLDING
BIN
DC
PRODUCT
PACKAGING

FIGURE C.2-8 FLOW DIAGRAM FOR DUST MILL-NO. 3

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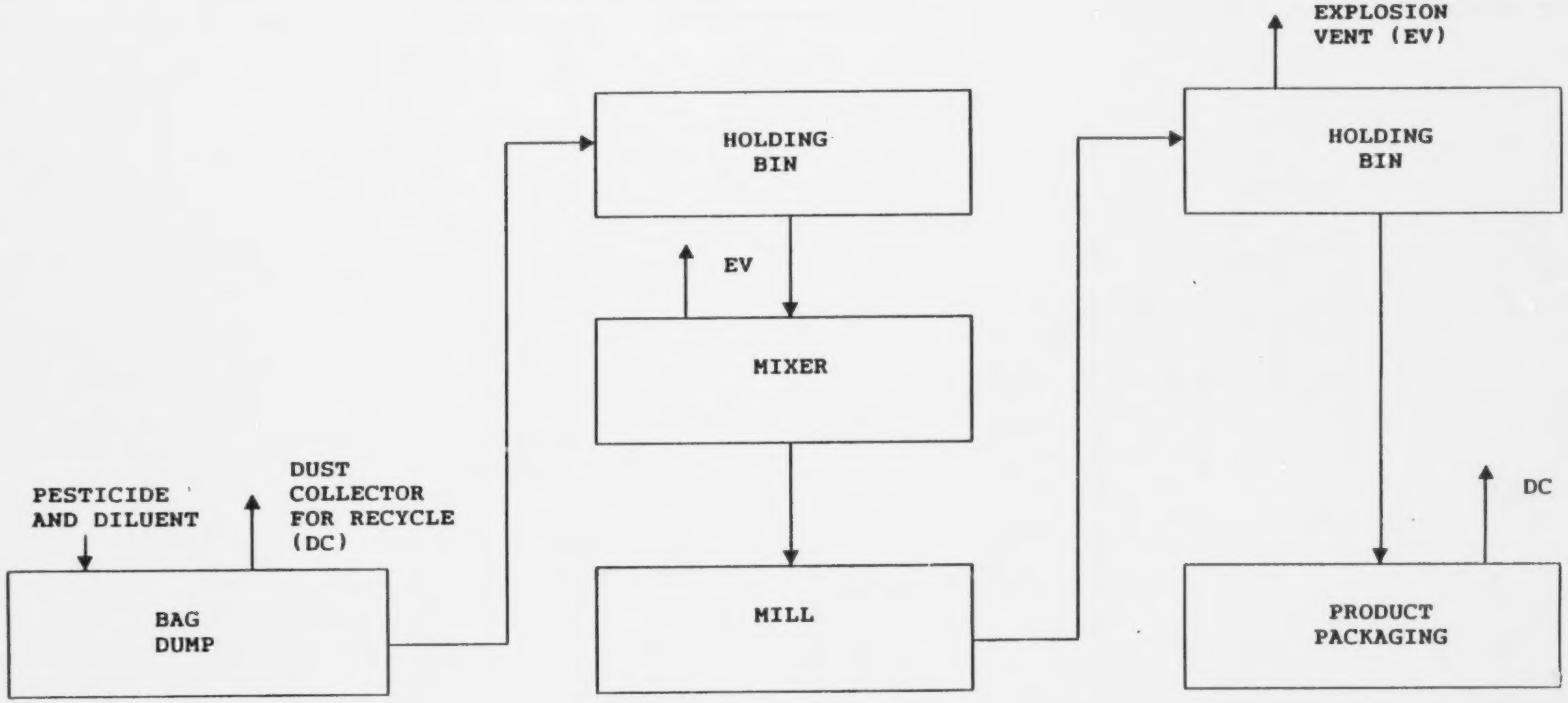
PESTICIDE
AND DILUENT
DUST
COLLECTOR
FOR RECYCLE
(DC)
BAG
DUMP
HOLDING
BIN
EV
MIXER
MILL
EXPLOSION
VENT (EV)
HOLDING
BIN
DC
PRODUCT
PACKAGING

FIGURE C.2-9 FLOW DIAGRAM FOR DUST MILL-NO. 4

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AND ENGINEERING, INC.

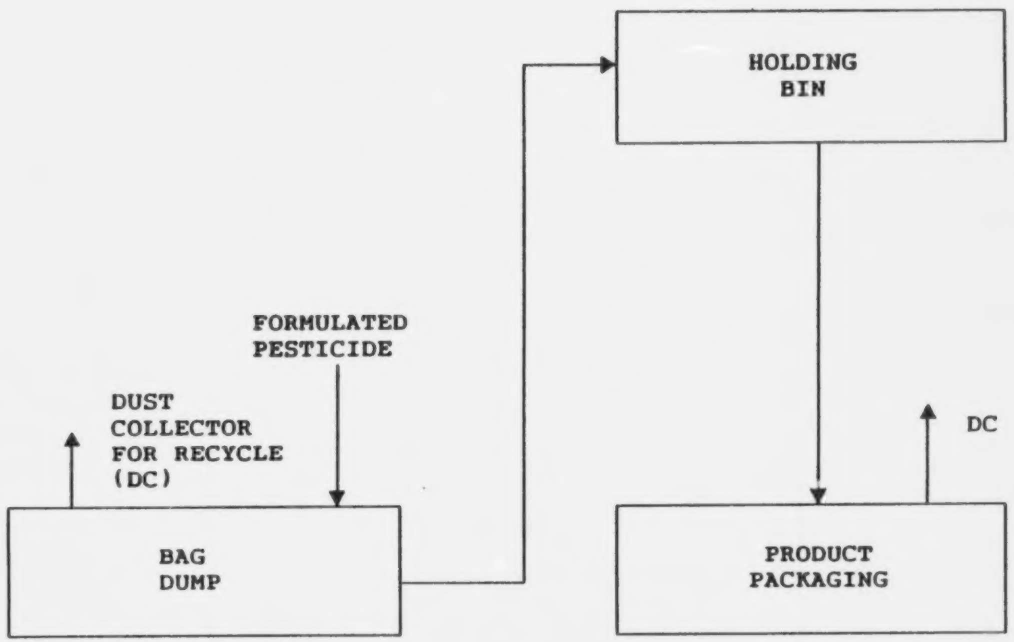
HOLDING BIN
FORMULATED PESTICIDE
DUST COLLECTOR FOR RECYCLE (DC)
DC
BAG DUMP
PRODUCT PACKAGING

FIGURE C.2-10 FLOW DIAGRAM FOR DUST REPACK MILL (MILL NO. 2A)

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Each dust mill has a dedicated dust collector which draws dust from the cut-in hopper and the bagging machine. As described in the preceding section, the central vacuum system is used to collect spilled product and general fugitive dust emissions in the dust mill area.

C.2.3.4 Liquids Formulation Process

The liquids processing area includes the sinox, two main liquids, micronutrients and oils buildings. In 1986, the liquids area formulated 1.7 million gallons of liquid pesticides.

The sinox process located in Building 48 houses two process mills, the sinox mill and the paraquat repackaging mill. Sinox mill processes are diagramed in Figures C.2-11 and C.2-12.

The sinox technical material is dinitrobutyl phenol. It is stored in a closed bulk storage tank located over a large sump adjacent to the building. The tank area is roofed. Technical material and diluents are added to a mixer via a barrel dump. They are mixed in a 2,500-gallon (gal) mixer and pumped to one of two batch holding tanks for dispensing and packaging. The diluents consist of water, xylene, methanol, and diesel fuel. Paraquat is only repackaged in the sinox building. Vapors drawn off the mixer and batch holding tanks for both the sinox and paraquat processes pass through activated carbon unit filters.

One of the two main liquids building contains four liquid formulation mills. The liquid mill process is diagramed in Figure C.2-13. Technical materials and diluents are loaded via a barrel dump station and gravity fed into the mixer. The diluents consist of oils, solvents, and water. After mixing, the pesticide is pumped to a holding tank for dispensing and

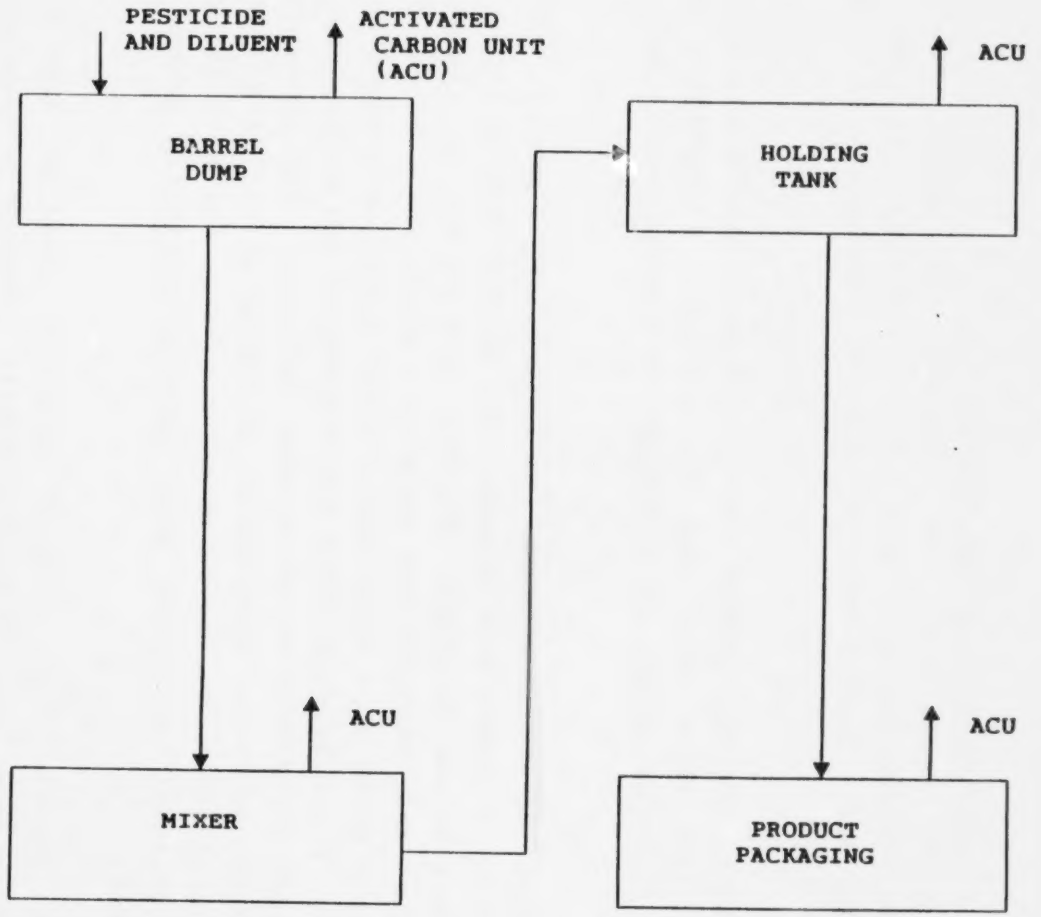
PESTICIDE
AND DILUENT
ACTIVATED
CARBON UNIT
(ACU)
BARREL
DUMP
HOLDING
TANK
ACU
MIXER
ACU
PRODUCT
PACKAGING
ACU

FIGURE C.2-11 FLOW DIAGRAM FOR SINOX PROCESS

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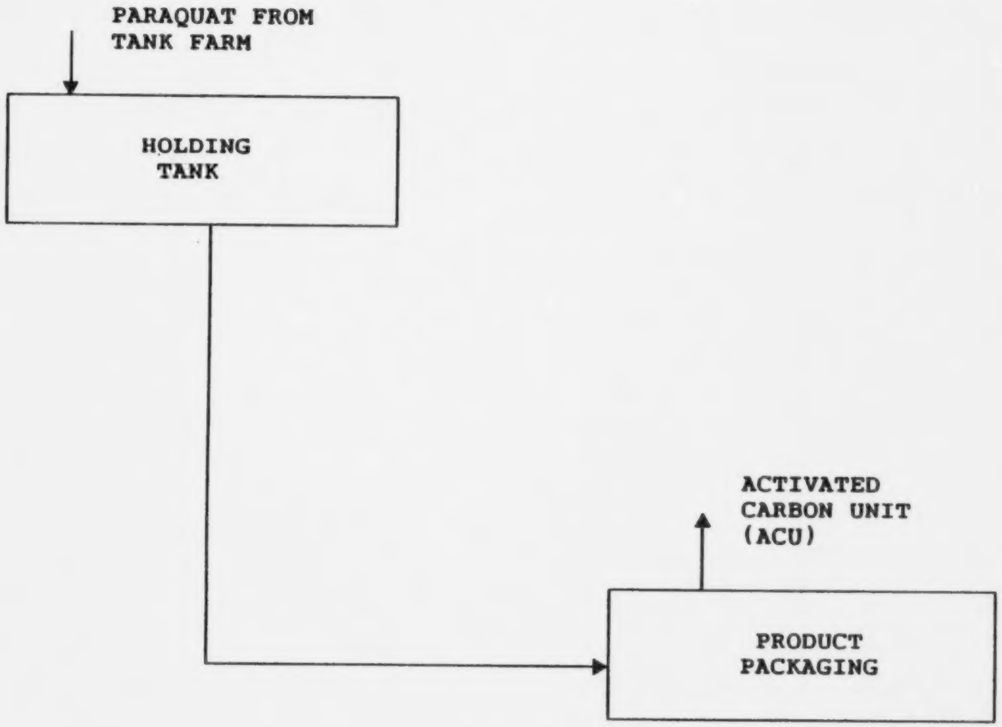
PARAQUAT FROM
TANK FARM
HOLDING
TANK
ACTIVATED
CARBON UNIT
(ACU)
PRODUCT
PACKAGING

FIGURE C.2-12 FLOW DIAGRAM FOR PARAQUAT REPACKAGING PROCESS

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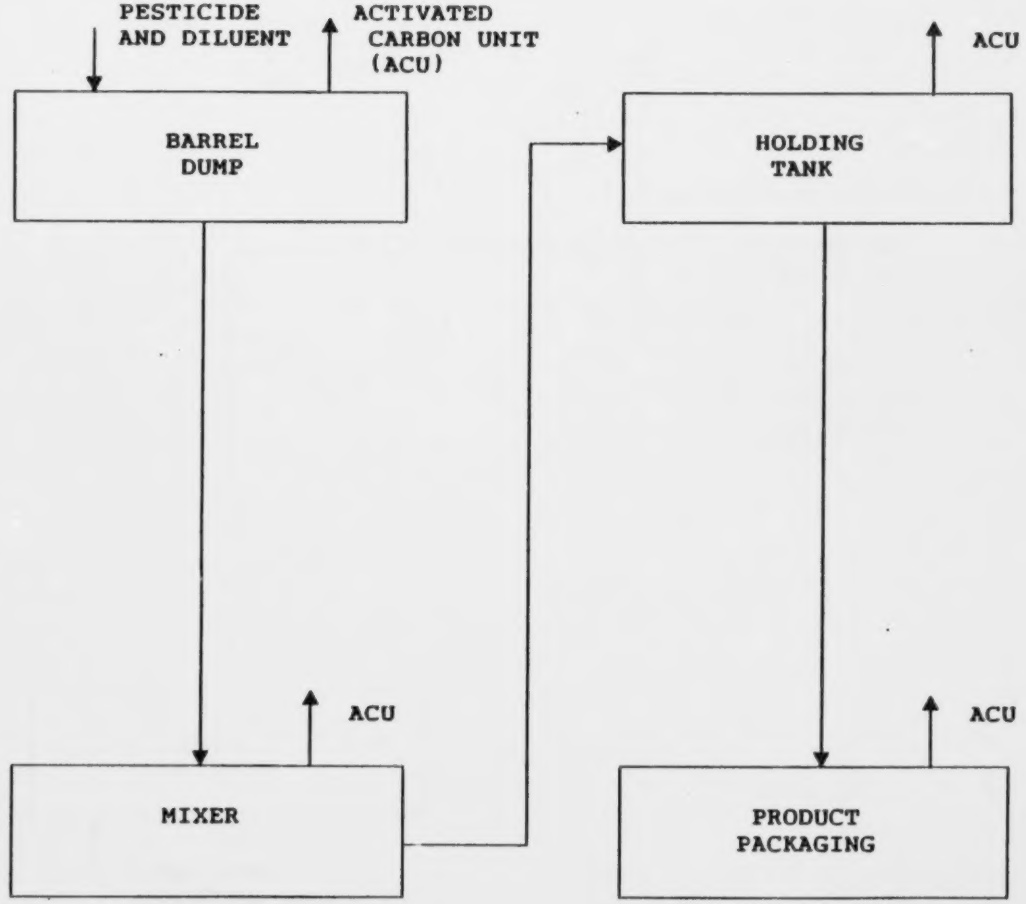
PESTICIDE
AND DILUENT
ACTIVATED
CARBON UNIT
(ACU)
BARREL
DUMP
HOLDING
TANK
ACU
MIXER
ACU
PRODUCT
PACKAGING
ACU

FIGURE C.2-13 FLOW DIAGRAM FOR MAIN LIQUID PROCESS

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packaging. Pesticide vapors are drawn off all portions of the liquids process and passed through an activated carbon filter.

The other main liquids building was formerly used to formulate kelthane, but was being renovated at the time of the audit. It was being renovated to provide various liquid formulating facilities similar to those described above and depicted in Figure C.2-13. Likewise, the micronutrients building was being renovated during the audit to provide similar formulating processes.

The oils building contains the oil blending process. In 1986, 200,000 gal of oil products were formulated at the plant. Various oils are shipped to the plant in bulk and are blended in a series of mixing tanks and packaged in smaller containers, typically 30-gal drums. Dedicated integral piping and tank draining practices prevent contamination of subsequent batches. However, because of poor market conditions, the oils operation was discontinued in September, after the onsite audit.

Supplemental to the oil blending operation is a drum or barrel washing/painting operation which is located adjacent to the oils building. Figure C.2-14 presents a schematic diagram of the barrel washing/painting operation. Barrels are first manually washed with a high-pressure hose to remove labels and excess oil. The barrels are then cleaned in a barrel washer, dried, painted in a water-curtain spray booth, and again dried. With the discontinuation of the blending operation, the barrel washing/painting operation has also been discontinued.

Support operations at the plant include a uniform laundry, steam cleaner, maintenance shop, quality control laboratory, bulk storage areas, and warehouses. The steam cleaner, which

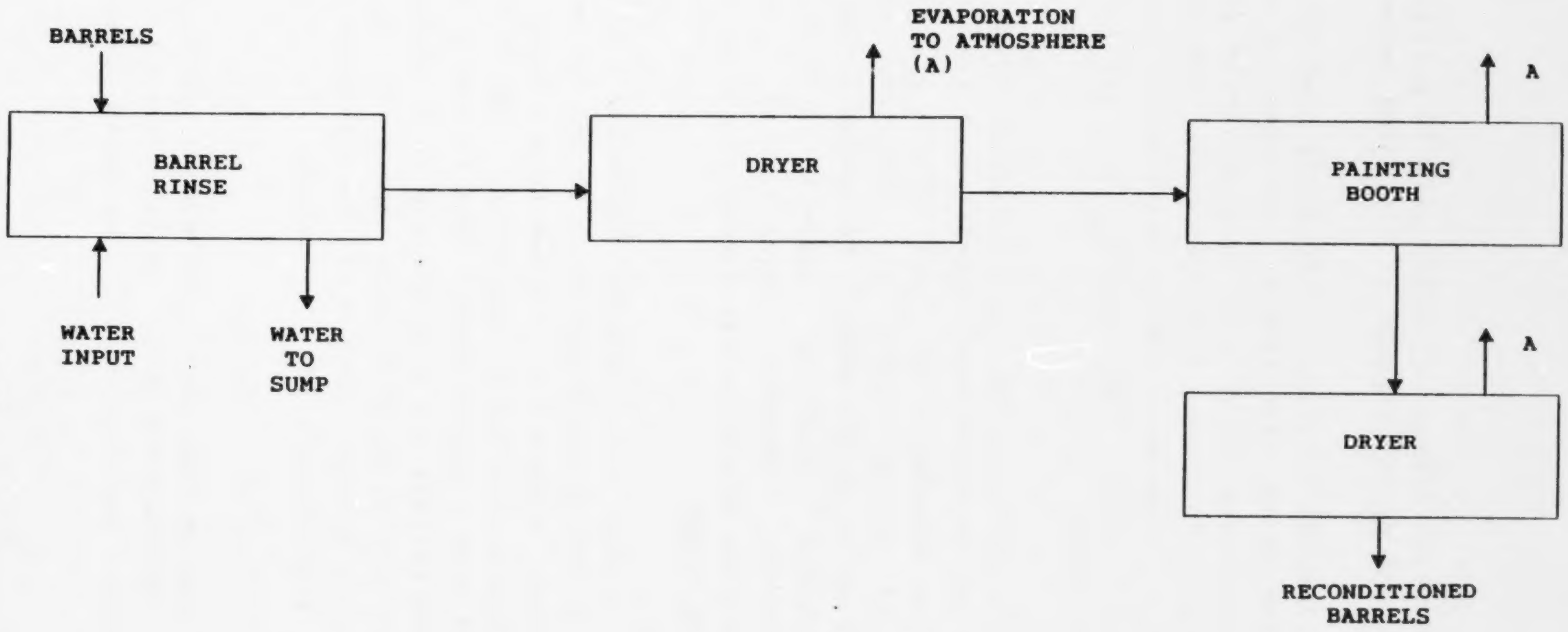
BARRELS
BARREL RINSE
WATER INPUT
WATER TO SUMP
DRYER
EVAPORATION TO ATMOSPHERE (A)
PAINTING BOOTH
A
A
DRYER
RECONDITIONED BARRELS

FIGURE C.2-14 FLOW DIAGRAM FOR BARREL WASHING OPERATION

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is portable, is mainly used for cleaning formulating equipment prior to performing maintenance on the equipment. It is also used to clean liquid mixing tanks in-place between formulating operations.

CHAPTER C.3.0
WASTE GENERATION, HANDLING, AND DISPOSAL

This chapter identifies the sources of hazardous wastes generation at the plant and describes the existing methods for waste handling and disposal. This information is presented by each major type of waste generated including dust, dust/granule mill flushing diluents, other solid wastes, and liquid wastes. Other solid wastes consist of empty packaging materials, lab wastes, and activated carbon filters.
The disposal costs for each of these wastes are also presented.

C.3.1 DUST

Each dust and granular pesticide formulation mill is equipped with a dedicated dust collection system. This system draws fugitive dust generated by the various mill components and recycles its to the previous component. For example, dust drawn from the mixer is routed to the cut-in hopper. Excess dust generated during the final phase of batch formulation is collected in a hopper. This excess dust is emptied from the hopper into a drum located underneath the hopper in an enclosed housing. The drum is normally a 30-gallon (gal) drum. The dust is sampled and analyzed for technical material from the current batch as well as technical material from the differing previous batch. If the dust contains technical material from the current batch and does not contain unacceptable amounts of the differing technical material from the previous batch, then the dust is held for recycling in subsequent formulations. However, if the dust cannot be recycled within a practical time because of product orders, then the dust is disposed of as a hazardous waste at an offsite approved hazardous waste disposal facility. Likewise, non-recyclable dust is disposed of as a hazardous waste at an offsite disposal facility. In addition to the individual mill dust collection systems, a central vacuum system serves both the granular and dust formulation buildings. Vacuum ports for this system are located near each dust and granular mill and dust collector hopper. During product formulation, operators will attach a hose to the port and vacuum dust and spilled product from around the mill area. When individual mill dust collector hoppers are emptied, a vacuum hose is attached to the drum housing under the hopper to draw off fugitive dust emissions. Material collected in the central vacuum system is emptied in the same manner as mill dust. Because the dust collected by the central vacuum system contains a variety of technical materials, recycling of the dust in subsequent formulations is not feasible. Therefore, it is disposed of as a hazardous waste at an offsite hazardous waste disposal facility.

The drums of non-recyclable dust are first transferred from the individual mill dust collectors and the central dust collection system to the hazardous waste accumulation area in the main warehouse. As a result of drum vibration during transport and gravity settling of the dust, the dust level drops in the drums. The drums are topped off with additional waste dust in the drum accumulation area and are then transported to an offsite hazardous waste disposal facility.

The firm of Chemical Waste Management is the most frequently used hazardous waste transportation and disposal contractor, with disposal occurring at the Kettlemen Hills disposal facility.

C.3.2 DUST/GRANULE MILL FLUSHING DILUENTS

As described in Chapter C.2.0, sand and clay diluents are used to flush the granule and dust mills, respectively, after a product formulation run to remove residual pesticides. The diluent is collected in drums and empty paper bags which previously contained inert materials. The diluent is sampled and analyzed in the same manner as that for dusts collected by the vacuum systems. Likewise, the diluent is recycled or disposed of in the same manner as the dust based on the analytical results.

C.3.3 OTHER SOLID WASTES

Other solid wastes consist of emptied paper bags, cartons, and steel drums; activated carbon filters from ventilation systems; floor sweepings; and laboratory wastes.

The emptied paper bags and cartons and activated carbon filters are collected daily from process areas and compacted in a 40 cubic yard (cy) compactor. The compacted waste are hauled "piggy back" in the 40-cy bins to an offsite approved hazardous waste disposal facility. The bins typically contain between 12,000 and 15,000 pounds of bulk waste.

The 30- and 55-gal drums are reused for collecting hazardous dusts and flushing diluents as described previously. Any drums which cannot be reused for collection of hazardous wastes are cleaned at the steam cleaning pad and are transported offsite to a drum recycling firm.

Spilled product floor sweepings are collected in drums and disposed of as a hazardous waste. Likewise, laboratory wastes are lab packed and disposed of as a hazardous waste.

C.3.4 LIQUID WASTES

Liquid wastes consist of process wastewater, stormwater runoff, and sanitary wastewater. A description of each of these waste streams including a discussion of the handling and disposal methods is presented in the following sections.

C.3.4.1 Process Wastewater

Process wastewater consists of mill clean-out rinse water, equipment washdown water, laundry wastewater, floor wash water, boiler blowdown, cooling tower blowdown, and steam cleaning pad wastewater. Process wastewaters are generally routed to building floor drains and/or centrally located sumps. They flow by gravity or are pumped to the main wastewater sump. From there, the wastewater is pumped to the above ground bulk liquid hazardous waste storage tank. The tank has a capacity of approximately 589,000 gal. The process wastewater is periodically hauled by tanker trucks to an offsite hazardous waste disposal facility.

A discussion of each individual source of process wastewater is presented in the following paragraphs.

C.3.4.1.1 Mill Clean-Out Rinse Water and Equipment Washdown Water

The liquid formulation tanks and mixing equipment are cleaned using the portable steam cleaner and water hoses between formulations of different pesticides. In addition, whenever a piece of equipment is removed from service for maintenance, it is decontaminated using the portable steam cleaner. Decontamination is performed either in-place or at the steam cleaning pad prior to transporting the equipment to the maintenance building. The wastewater generated by these cleaning operations is collected and directed to the bulk hazardous waste storage tank.

C.3.4.1.2 Laundry Wastewater

The plant operates a laundry with two industrial grade washers and dryers onsite for the cleaning of process employee overalls. The laundry wastewater is discharged to a nearby above ground tank. From this tank the wastewater is pumped to the bulk hazardous waste storage tank.

C.3.4.1.3 Floor Wash Water

To clean up spills in the liquids formulating buildings, water hoses and the steam cleaner are used to wash down the spills to floor drains which lead to sumps. From the sumps, the wastewater is pumped to the bulk hazardous waste storage tank.

C.3.4.1.4 Boiler and Cooling Tower Blowdown

Blowdown from the boiler and cooling tower is pumped to the bulk hazardous waste storage tank. The cooling tower blowdown is handled as a hazardous waste because of the potential for fugitive pesticide dust emissions to become entrained in the cooling tower water. Although the boiler blowdown is very likely not a hazardous waste stream, it is treated as such only because no other discharge options are readily available. The onsite septic tank/drainfield system reportedly does not have adequate capacity to accept the blowdown. In addition, plant personnel are reluctant to apply for a discharge permit because of past difficulties experienced in the application for discharge of treated process wastewater.

C.3.4.1.5 Steam Cleaning Pad Wastewater

Wastewater generated by the cleaning of drums and other equipment at the steam cleaning pad is routed to the bulk hazardous waste storage tank.

C.3.4.2 Stormwater Runoff

Of the 12.5-acre developed area of the plant, stormwater runoff from the 2-acre plant parking lot drains to a percolation pond located near the main gate of the plant. Stormwater runoff from the remaining 10.5-acre process area is collected through the central sump system and pumped to the bulk hazardous waste storage tank for disposal as hazardous waste. The exception to this runoff pattern is the runoff from the north side of the maintenance building roof. The roof downspouts discharge to gravel splashpans in a grassy area adjacent to the building.

C.3.4.3 Sanitary Wastewater

Sanitary wastewater generated at the plant is discharged to two onsite septic tank/drainfield systems. The sanitary waste stream includes wastewater generated by the employee shower. Employees engaged in formulating operations are required to shower and change cotton overalls before lunch and shower again before leaving after work. The number of employees engaged in formulating operations ranges from approximately 60 to 120, depending on seasonal fluctuations in production.

C.3.5 WASTE QUANTITIES AND DISPOSAL COSTS

Quantities and disposal costs for the hazardous wastes identified in the preceding sections are presented in this section. The waste quantities are based on summary data provided by the plant which consist of annual quantities by solid and liquid wastes for the period of 1981 through 1985. In addition, best engineering judgement was applied to estimate quantities of specific types of process wastes. Table C.3-1 presents the annual waste quantity summary data by waste media. As shown in this table, the annual quantity of solid waste generated has decreased from 2,080.8 tons in 1981 to 467 tons in 1985, a 78 percent decrease. This reduction in solid waste generation resulted from aggressive waste minimization efforts by the plant, particularly relative to dust generation. Numerous equipment modifications and procedural changes were implemented to control the generation of hazardous dust.

Table C.3-1. Annual Waste Quantity Summary Data

Hazardous Waste Media	Waste Quantity (tons)				
	1981	1982	1983	1984	1985
Solid	2080.8	1001.2	747.4	526.0	467
Liquid *	3921.2	6444.2	15,259.8+	6024.9	7,000
Total	6002.0	7445.4	16,007.2	6550.9	7,467

* Includes stormwater runoff from plant area.

+ Includes 1,666 tons from pre 1982 storage.

Source: Plant C, 1985 and 1986.

Interpretation of the liquid waste quantity data in Table C.3-1 to identify temporal trends over the 5-year period was not possible because neither the volume of stormwater runoff; nor the volume of process wastewater could be estimated within reasonable confidence limits. Reasonable confidence limits could not be achieved because the following data were not available to allow the estimation of meaningful waste quantities: 1) Changes in the total plant area contributing runoff; and 2) Variability in process waste stream generation rates resulting from production fluctuations and implementation of waste minimization techniques.

However, the total volume of process wastewater generated on an average annual basis was reported to be about 500,000 gal per year, or 2,000 tons per year. This average generation rate was reported to be a relatively accurate estimate for 1984 and 1985. In addition, minimal changes in plant drainage areas have occurred since 1984. Therefore, for the 2-year period of 1984 and 1985 the difference between the total liquid waste volume and the average annual volume of process wastewater should be a relatively accurate estimate of the volume of stormwater runoff. Furthermore any changes in the volume of runoff between 1984 and 1985 should be directly proportional to the change in annual rainfall. As shown in Table C.3-2, which presents the annual stormwater runoff quantity and rainfall for 1984 and 1985, this relationship holds true confirming the low variability in annual process wastewater generation between 1984 and 1985. The data presented in Table C.3-2 also indicates that in 1984 and 1985, stormwater runoff accounted for about 70 percent of the total liquid waste.

Table C.3-2. Estimated Quantity of Process Wastewater and Stormwater Runoff in 1984 and 1985

YEAR	TOTAL LIQUID WASTE (TONS)	TOTAL PROCESS WASTEWATER (TONS)	STORMWATER RUNOFF (TONS)	RAINFALL (INCHES) *
1984	6,024.9	2,000	4,024.9	6.77
1985	7,000	2,000	5,000 +	8.40 **

* Recorded at nearby airport
+ 19.5 percent increase over 1984 stormwater runoff quantity.
** 19.4 percent increase over 1984 rainfall.

Source: Plant C, 1985 and 1986
ESE, 1986

Because considerable waste minimization had already occurred relative to solid hazardous waste, and minimal potential for further solid waste minimization was found to exist at this plant, additional waste quantification efforts focused on the liquid waste streams. Quantification of the various liquid process waste streams was based primarily on reported typical wastewater generation rates. In addition, best engineering judgement was used to estimate waste quantities in the absence of available waste generation information. Table C.3-3 presents the estimated annual volume of each process waste stream and stormwater runoff. As shown in Table C.3-3, almost 90 percent of the total process wastewater volume consists of laundry wastewater. Each of the other process waste streams contributes less than 5 percent. On an average annual basis, stormwater runoff contributes about 75 percent of the total liquid waste volume, and approximately 97 percent of the total liquid waste volume consists of runoff and laundry wastewater.

Table C.3-4 presents annual waste disposal costs for the various forms of waste as disposed of by hauling offsite to the Chemical Waste Management hazardous waste disposal facility near Kettleman City, California. The costs are based on 1984 waste quantities as this database was the most recent and complete. However, 1986 unit disposal costs were used to reflect more current overall costs. As shown in Table C.3-4, the cost for disposing process wastewater including stormwater runoff is approximately 75 percent of the total. The remaining 25 percent consists of solid waste disposal costs.

Table C.3-3. Estimated Volume of Liquid Process Waste Streams and Stormwater Runoff

WASTE STREAM	Estimated Annual Volume		
	gal	% of Tot. Process Wastewater	% of Tot. Liquid Waste
Mill Cleanout Rinse Water and Equipment Washdown Water	11,000	2.2	0.6
Floor Wash Water	9,000	1.8	0.4
Steam Cleaning Pad Wastewater	15,000	3.0	0.8
Laundry Waste-Water	441,000	88.2	22.0
Boiler & Cooling Tower Blowdown	24,000	4.8	1.2
TOTAL PROCESS WASTEWATER	500,000	100	25
Stormwater Runoff **	1,500,000	---	75
TOTAL LIQUID WASTE	2,000,000	---	100

*Based on average annual rainfall of 10.52 inches per year recorded at a nearby airport.

Table C.3-4. Annual Waste Disposal Costs

Waste Type	Annual Waste Quantity *	Unit Disposal Cost +	Annual Disposal Cost	% of Tot Cost
Drummed Solids	2,057 drums	$65/drum	$133,705	9.4
Compacted Solids	36 bins	$5,400/bin	$194,400	13.7
Pallets of Solids **	93 pallets	$260/pallet	$ 24,180	1.7
Process Waste Water++	1,445,300 gal	$0.72/gal	$1,040,616	75.2
TOTAL COST			$1,392,901	

* 1984 data
+ Based on disposal at Chemical Waste Management disposal facility near Kettleman City, California.
** Palletized and plastic wrapped paper bags containing contaminated flushing diluents
++ Including stormwater runoff.

Source: Plant C, 1984; ESE, 1986

CHAPTER C.4.0
AUDIT FINDINGS AND RECOMMENDATIONS

This chapter presents the findings of the audit in terms of hazardous waste minimization techniques recently implemented by the plant. Recommendations for further waste reduction through source controls, recycling, and treatment are also presented. Where information was available, cost/benefit data are presented for the various waste minimization techniques implemented by the plant.

C.4.1 EXISTING WASTE MINIMIZATION TECHNIQUES

The most prominent waste minimization techniques implemented at the plant are those which control the generation of hazardous dusts in the formulation of dust and granular pesticides. These techniques consist of the installation of dedicated dust collection baghouses on each dust/granule formulating mill; the installation of enclosed cut-in hoppers, conveyors, elevators, mixers, and holding tanks; the recycling of dust collected from each mill component to the preceding component; and the reuse of the dust collected in the baghouse hopper for subsequent formulations to the maximum extent that is practically feasible.

As described in Chapter C.3.0, the significant reduction in the volume of solid hazardous waste generated since 1981 is mainly attributable to the implementation of these dust control techniques.

Other solid waste reduction techniques employed by the plant consist of the use of returnable bulk diluent containers; the installation of a compactor to reduce the volume of bulky wastes such as emptied paper bags, cardboard drums and spent activated carbon filters; and the recycling of empty drums. The returnable bulk diluent containers are used primarily for the sand and clay diluents used in formulating dust and granular pesticides.

The compactor was installed mainly because the disposal costs for the bins of bulk waste are based on a unit volume basis rather than a unit weight basis, and waste volume reduction would result in reduced disposal cost. The compactor was installed in 1983 for a cost of approximately $60,000. The savings realized from the reduced disposal costs offset the capital cost of the compactor in 4 months.

Any empty 55-gallon drum which previously contained pesticide is either reused for collecting hazardous waste, or washed and shipped to an offsite drum recycler. As described previously, drums shipped to the offsite recycler are first cleaned at the steam cleaning pad. Plant personnel reported that the firm of Rose Cooperage located in Los Angeles, CA is the only drum recycling firm in the state that will accept drums that formerly contained pesticides.

Waste reduction measures that have been implemented relative to liquid process wastes include the use of portable steam cleaners to clean mixing tanks rather than using the batch-boil method; the use of spray nozzles on hoses used for rinsing mixing and other process equipment, and floor washing; and recycling of equipment rinse waster as diluent for subsequent formulations when practicable. The reduction in liquid process wastes resulting from the implementation of these techniques is not known as historical waste volume data are not available for the specific liquid waste streams.

Inspection of the liquid formulating areas indicated that not all hoses used for equipment washdown and floor washing were equipped with nozzles. Some were not even equipped with threaded fittings for nozzles. Consequently, further liquid waste volume reduction could be achieved by installing nozzles on all hoses at the plant. A high pressure water knife nozzle could significantly reduce the liquid volume. This would generate a more concentrated wastewater that could be used in subsequent formulations.

A general observation of the waste minimization audit was that past waste minimization efforts apparently focused more on the generation and disposal of solid wastes than on liquid process waste generation and disposal. This observation is based on the extent of capital improvements of hazardous dust collection equipment compared to that related to liquid waste minimization. In the absence of historical waste volume data for specific liquid waste steams, it is not possible to further substantiate this observation by comparing the percentage reduction of liquid waste streams versus solid waste streams.

Another significant audit finding is that many of the higher strength liquid process wastes, such as equipment rinse water, are generated in almost negligible volumes compared to the volume of plant stormwater runoff that is collected and handled as a hazardous waste. Consequently, any reductions in process wastewaters that have occurred through the implementation of waste minimization measures are masked by the volume of stormwater runoff that is commingled with the process wastewater.

According to plant personnel, past efforts to obtain a discharge permit for the stormwater runoff have been unsuccessful because of concern over pesticide levels in the runoff. Consequently, the plant is currently conducting treatability testing of activated carbon for pesticide removal from process wastes, including the runoff.

C.4.2 RECOMMENDED WASTE SOURCE REDUCTION TECHNIQUES

The recommendations presented below were developed for minimizing or eliminating hazardous waste at the source of generation.

C.4.2.1 Liquid Waste Sources

1. Use mopping of floors in liquid pesticide formulating areas with dedicated mops and squeegees to minimize the use of water hosing for floor washing. This practice will minimize the volume of floor wash water generated.
2. Install spray nozzles on all hoses to increase equipment rinsing efficiency thereby minimizing the volume of spent rinse water. This recommendation could include the use of a water-knife type spray nozzle equipped with a high pressure booster pump. The resulting wastewater would be more concentrated and could be used in subsequent formulations. The use of wiper blades to physically wipe down the inside of the mixing tanks could also be included as part of this recommendation.
3. Collect and reuse equipment rinse water for repetitive rinsing to minimize the volume of spent rinse water. This recommendation would involve the installation of rinse water holding tanks to facilitate its reuse, and possible two stage rinsing using more contaminated rinse water for the first stage of rinsing, and less contaminated rinse water for the final rinse.
4. Install flow meters on process water lines in each liquid pesticide formulating area to monitor water usage and the effects of various waste minimization techniques during trial implementation periods. Maintain a formal waste minimization program requiring operators to routinely record meter readings and waste quantities, and periodically review this data with management.
5. Use disposable coveralls, such as Tyvek suits, instead of cotton overalls for personnel engaged in formulating

operations to minimize laundry wastewater.

6. Collect and analyze samples of boiler and cooling tower blowdowns to determine if these waste streams are characteristic hazardous wastes. If nonhazardous, dispose of by discharge to one of the septic tank/drainfield systems.
7. Monitor stormwater runoff flow and quality. This monitoring may indicate that the runoff is uncontaminated during the latter part of the wet season because of the contaminant flushing. If so, the runoff should be handled as a nonhazardous waste during this time period. This will require that the runoff control system be modified to allow segregation of the runoff from process wastewater.

C.4.2.2 Solid Waste Sources

In the granule and dust mill flushing operation between batches, change from once through diluent flushing to repetitive flushing with a smaller volume of diluent. This recommendation may involve the installation of dedicated holding tanks for the used diluents, and could also include the use of two stage flushing. Furthermore, the establishment of a formal waste minimization program to periodically review waste generation by granule and dust mill operations should be considered.

C.4.3 RECOMMENDED WASTE RECYCLING TECHNIQUES

The findings of the audit indicated that the plant is effectively recycling diluents used for decontaminating formulating equipment between batches to the extent that is practically feasible. This applies to clays and sand for dust/granule formulations, and water and solvents for liquid formulations. It was also determined that the plant is currently conducting pilot-scale activated carbon treatability studies for the combined process wastewater, including plant runoff, to produce an effluent that could be reused in the plant. It is recommended that these studies be continued and expanded as necessary to evaluate other applicable treatment technologies to evaluate reuse of the effluent in the plant. These studies should also be designed to support the discharge of the effluent to surface water or to a publicly-owned treatment works (POTW) should the sewer system be extended near the plant in the future.

C.4.4 RECOMMENDED MANAGEMENT/EMPLOYEE INITIATIVES

The recommendations presented below were developed for minimizing hazardous waste at the source through management and employee initiatives.

1. Provide routine waste reduction training for operating employees.
2. Establish an incentive compensation system whereby employees are rewarded for reducing waste generation, in proportion to the reduction in the company's waste management costs.

C.4.5 POTENTIAL ECONOMIC BENEFITS

The potential economic benefits of implementing the recommended waste source reduction and recycling techniques, described in Sections C.4.2 and C.4.3, respectively, were assessed by comparing the annual implementation costs and the resulting annual savings in waste disposal costs. The estimated implementation costs include the capital cost for any new equipment or plant improvements, as well as the operation and maintenance costs associated with the recommended technique. The capital cost was annualized using an interest rate of 10 percent and a 30 year period. The annual implementation cost is the sum of the annualized capital cost and the annual operation and maintenance costs.

Recommendations 1 through 4 under Liquid Waste Source reduction techniques (Section C.4.2.1) were combined for the economic benefit assessment because they are all closely related and pertain to the reduction of equipment rinse water and floor wash water. The estimated implementation cost for these techniques is approximately $8,400 per year, the majority of which is for the installation, operation, and maintenance of spent rinse water collection systems to facilitate repeat use of the rinse water. Based on a unit disposal cost of $0.72/gallon, the implementation of these techniques would have to result in a wastewater reduction of almost 11,700 gallons per year to offset the implementation cost. This reduction represents approximately 60 percent of the current wastewater generation by equipment rinsing and floor washing operations. The success of these waste reduction techniques will mainly hinge on the effectiveness of repetitive use of the spent equipment rinse water, and consideration should be given to trial implementation of this technique on one of the pesticide formulating operations. The trial implementation would involve the installation of a temporary collection and storage system for the spent rinse water for subsequent reuse. It would also involve testing of repetitive use of the spent rinse water to determine the number of rinse cycles that could be used before the rinse water becomes too contaminated to allow effective rinsing.

Recommendation 5 under Liquid Waste Source reduction techniques (Section C.4.2.1) involves the use of disposable coveralls such as Tyvek suits, rather than cotton coveralls, to minimize the volume of laundry wastewater. Because the disposable coveralls do not generally breathe as well as the cotton coveralls, they would likely be too uncomfortable during the warmer months of June through September. However, the use of disposable coveralls during the remaining months would minimize the volume of laundry wastewater. Assuming the use of 120 Tyveks per day for 165 days per year, the annual cost for the Tyveks would be approximately $47,000. The disposal cost for the used Tyveks as a hazardous waste would be about $12,000 per year. In addition, the disposal cost for the laundry wastewater generated during the months of June through September based on a unit disposal cost of $0.72/gallon would be approximately $106,000. Therefore, the total cost of using disposable coveralls except during the four warmer months of the year would be about $165,000. At present, the annual disposal cost for the laundry wastewater is approximately $318,000, based on a unit disposal cost of $0.72/gallon. Consequently, the use of the disposable coveralls as described above would result in an annual savings of about $153,000. Although this recommendation appears to be very economically beneficial, Plant C should regularly evaluate the impact of the landfill ban program which could eventually prohibit landfill disposal of the contaminated Tyvek suits. In evaluating this recommendation, Plant C should also consider the waste classification of the Tyvek suits. Characterization of the contaminated Tyveks should be performed, as recommended for the pesticide-contaminated rags generated by Plant B (see Appendix B), to determine the waste classification and appropriate waste disposal method.

Recommendation 6 under Liquid Waste Source reduction techniques (Section C.4.2.1) consists of the sampling and analysis of the boiler and cooling tower blowdowns to determine if these waste streams are characteristic hazardous wastes. At present, these waste streams, which combined amount to 24,000 gallons per year, are disposed of as a hazardous waste at an annual cost of approximately $17,000. The collection and analysis of four samples of each of the two waste streams are recommended to provide a representative database for the hazardous waste determination. The estimated cost for collecting and analyzing eight samples for pesticides analysis is approximately $8,000. If these waste streams are found to be nonhazardous, then these waste streams could possibly be discharged to one of the existing septic tanks/drainfield systems. The installation of plumbing required for directing these waste streams to the septic tanks is estimated to be about $4,000 (annualized cost of approximately $400 per year). Therefore, as nonhazardous wastes, these waste streams could be disposed of at a cost of about $400 per year, with a first year sampling and analysis cost of $8,000. These cost represent a savings of $8,600 during the first year of implementation, and an annual savings of over $16,000 per year thereafter.

Recommendation 7 under Liquid Waste Source reduction techniques (Section C.4.2.1) involves monitoring of stormwater runoff flow and quality throughout the wet season. The purpose of this monitoring program is to determine if the runoff is nonhazardous, which may be the case particularly in the latter portion of the wet season. In order to develop a meaningful cost estimate for monitoring the stormwater runoff, an analysis of the drainage systems would be required. This analysis may indicate that numerous monitoring locations may be warranted to adequately investigate the potential contaminant source areas in the drainage systems. Even though the costs of such a monitoring program may be considerable, it is possible that it could be easily offset by the savings that may be realized in the event that some of the runoff is determined to be nonhazardous.

Under the Solid Waste Source reduction techniques presented in Section C.4.2.2, the use of repetitive diluent flushing of granule and dust mills rather than once through flushing was recommended. The repetitive flushing would be performed with a smaller volume of diluent than that used for the once through flushing to minimize the volume of spent diluent generated. A meaningful cost analysis of this recommended technique is not possible until a limited amount of trial implementation is performed. Trial implementation would involve the collection and repeated reuse of the diluent to determine the number of flushes that can be performed before the diluent becomes too contaminated to allow effective cleaning of the mill.

As described in Section C.4.3, process wastewater treatability studies are currently being performed to evaluate reuse of the treated effluent as process water. The recommendation of continuing and possibly expanding these studies is based on the significant economic benefit that could potentially be obtained considering the high cost of liquid waste disposal as a hazardous waste. If not currently being considered, the segregation and treatment of the lower strength wastewaters, particularly stormwater runoff, may also be a very economically attractive option compared to the option of treating the combined process waste streams. This is supported by the large volume of stormwater runoff, which averages about 1,500,000 gallons per year and represents approximately 75 percent of the combined liquid waste volume.

At present, about $1.4 million is spent each year for the disposal of the process wastewater, including runoff, as a hazardous waste. Completion of the treatability and associated engineering feasibility studies will be required to perform a meaningful economic analysis of the various wastewater segregation/treatment/recycle options relative to the current wastewater disposal practice.

The recommended management/employee initiatives to minimize hazardous waste generation presented in Section C.4.4 involve the provision of waste reduction training and incentive compensation programs for operating employees. The cost of these programs will depend on the level of training to be provided, and the type and magnitude of the incentive compensation systems. Further evaluation of the employee training needs and overall compensation system at Plant C, as well as the anticipated waste management savings resulting from the implementation of these programs, is required to perform a meaningful cost/benefit analysis of this recommendation. Nevertheless, it is reasonable to assume that some long term benefit would be gained in the form of reduced waste management costs by implementing these types of employee programs.

APPENDIX D

SUMMARY OF PLANT AUDITS
HAZARDOUS WASTE REDUCTION STUDY OF PESTICIDE FORMULATING INDUSTRY IN CALIFORNIA

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CHAPTER D.1.0
INTRODUCTION

The objectives of the waste minimization audits of the pesticide formulating plants were to:

1. Gather site specific information concerning the generation, handling, storage, treatment, and disposal of hazardous waste;
2. Evaluate existing waste reduction practices;
3. Develop recommendations for waste reduction through source control, treatment, and recycling techniques; and
4. Assess costs/benefits of existing and recommended waste reduction techniques.

The first step in conducting the audits was the selection of the pesticide formulating plants, and contacting the plants to solicit voluntary participation in the audit study. Plant selection emphasized small businesses which generally lack the financial and/or internal technical resources to perform a waste reduction audit. One relatively large plant was also selected for study because it offered the opportunity to evaluate a wide variety of pesticide formulating operations, as well as a number of in-place waste reduction measures. A total of three plants were audited.

Appendices A through C contain each of the individual audit reports for these plants. However, all references to the name and location of the plants identified above have been removed from the individual audit reports to protect confidentiality as requested by plant personnel. The plants are identified as Plants A, B, and C.

During each of the plant audits, the audit team observed pesticide formulating operations; inspected waste management facilities; interviewed the plant manager, environmental compliance personnel, and operations supervisors; and reviewed and copied records pertinent to waste generation and management. The audits were performed by one or two engineers over a 1- to 3-day period depending on the size and complexity of the formulating and waste management operations.

Chapter D.2.0 of this summary report presents an overview of the plants audited. A discussion of the existing and recommended waste minimization techniques for the three plants is presented in Chapter D.3.0. Chapter D.3.0 also provides a summary discussion of the potential economic benefits of the recommended waste reduction techniques.

CHAPTER D.2.0
OVERVIEW OF PLANTS

A brief overview of the audited pesticide formulating plants including a discussion of the types of pesticide formulating performed, the general size of the plants, the raw materials utilized, the types and quantities of hazardous waste generated, and current waste management practices is presented in the following sections.

D.2.1 PLANT DESCRIPTIONS

Plants A and B have pesticide formulating and packaging operations that cover an area of less than 1 acre, whereas Plant C has formulating and packaging operations covering an area of approximately 10 acres. Each of the two smaller plants formulate no more than three different pesticide formulations. Plant C currently formulates over 600 different pesticide formulations.

Plant C formulates liquid and solid pesticide formulations using a wide variety of active pesticide ingredients. Liquid formulations consist of water- and solvent-based formulations, and solid formulations are in dust and granule form. Plant A formulates only dust/granule form herbicide/fertilizer mixtures by blending liquid Trimec, Trimec dust, and Dimethyl-T dust with various dust/granule fertilizers. Plant B formulates only xylene-based pesticides with malathion and diazinon as the active ingredients.

D.2.2 WASTE GENERATION, HANDLING, AND DISPOSAL

Table D.2-1 presents the types of hazardous waste generated by Plant A. Waste quantity estimates and management methods are also presented. This same information is presented in Tables D.2-2 and D.2-3 for Plants B and C, respectively.

Table D.2-1. Plant A Waste Generation and Management

Types of Hazardous Waste	Annual Waste Quantity Estimate	Existing Management Method
Vacuum System Dust	10 drums*	Reused in subsequent formulations
Empty bags, cartons, and drums* previously containing pesticides	5 drums*	Bags and cartons compacted in drums which are disposed of in a Class I landfill
Wastewater from equipment cleaning	20 gallons	Injected into subsequent formulations

*55-gallon drums

Table D.2-2. Plant B Waste Generation and Management

Types of Hazardous Waste	Annual Waste Quantity Estimate	Existing Management Method
Rags used to wipe down mixing tank	10 to 20 pounds	Disposed of in Class III landfill

Table D.2-3. Plant C Waste Generation and Management

Types of Hazardous Waste	Annual Waste Quantity Estimate	Existing Management Method
Mill clean-out rinse water and equipment washdown water	11,000 gallons	Disposed of at a Class I landfill
Floor wash water	9,000 gallons	Disposed of at a Class I landfill
Steam cleaning pad wastewater	15,000 gallons	Disposed of at a Class I landfill
Laundry wastewater	441,000 gallons	Disposed of at a Class I landfill
Boiler & cooling tower blowdown	24,000 gallons	Disposed of at a Class I landfill
Stormwater runoff	1,500,000 gallons	Disposed of at a Class I landfill
Contaminated dust and granules	2,080 drums*	Dust that is collected by vacuum systems, and dust/granules used to flush mills between different formulations are reused in subsequent formulations or disposed of in a Class I landfill, depending on the extent of contamination
Other solid wastes +	1,440 cubic yds (240 tons)	Disposed of in a Class I landfill

* This estimate is of waste that is disposed of and does not include any that is reused.

+ Includes pesticide-contaminated empty packaging materials (paper bags, cartons, and steel drums), spent activated carbon filters from ventilation systems, floor sweepings, and laboratory wastes.

Source: Plant C, 1986 and ESE, 1986.

CHAPTER D.3.0
AUDIT FINDINGS

This chapter summarizes the findings of the three plant audits, the waste reduction recommendations developed as a result of the audits, and the potential economic benefits of implementing the recommendations.

D.3.1 EXISTING WASTE MINIMIZATION TECHNIQUES

Plant A utilizes a dust vacuum system to collect fugitive dust emissions from the one dust/granule pesticide formulating and packaging operation. The dust is used in subsequent formulations. The wastewater generated by the periodic steam cleaning of the formulating mill is also used in subsequent formulations.

Plant B had no waste minimization techniques in practice at the time of the audit, although the only waste generated consists of about 20 pounds of pesticide-contaminated rags per year. The rags are used to decontaminate the 40-gallon mixing tank between different formulations, and are disposed of in a Class III landfill.

The most prominent waste minimization techniques implemented at Plant C are those which control the generation of hazardous dusts in the formulation of dust and granular pesticides. These techniques consist of the installation of dedicated dust collection baghouses on each dust/granule formulating mill; the installation of enclosed cut-in hoppers, conveyors, elevators, mixers, and holding tanks; the recycling of dust collected from each mill component to the preceding component; and the reuse of the dust collected in the baghouse hopper for subsequent formulations to the maximum extent that is practically feasible.

In addition, any empty 55-gallon drum that previously contained pesticide at Plant C is either reused for collecting hazardous waste, or washed and shipped to an offsite drum recycler. Drums shipped to the offsite recycler are first steam cleaned.

Waste reduction measures that have been implemented relative to liquid process wastes at Plant C include the use of portable steam cleaners to clean mixing tanks rather than using the batch-boil method; the use of spray nozzles on hoses used for rinsing, mixing and other process equipment, and floor washing; and recycling of equipment rinse water as diluent for subsequent formulations when practicable.

Another significant audit finding for Plant C is that many of the higher strength liquid process wastes, such as equipment rinse water, are generated in almost negligible volumes compared to the volume of plant stormwater runoff that is collected and handled as a hazardous waste. Consequently, any reductions in process wastewaters that have occurred through the implementation of waste minimization measures are masked by the volume of stormwater runoff that is commingled with the process wastewater.

According to plant personnel, past efforts to obtain a discharge permit for the stormwater runoff have been unsuccessful because of concern over pesticide levels in the runoff. Consequently, the plant is currently conducting treatability testing of activated carbon for pesticide removal from process wastes, including the runoff.

D.3.2 RECOMMENDED WASTE MINIMIZATION TECHNIQUES

Plant A is currently employing waste minimization techniques to the maximum extent feasible, and no additional waste reduction methods were developed as a result of the audit.

However, it was recommended that consideration be given to mechanical compaction of the empty pesticide containers, consisting of paper bags and cardboard cartons, in 55-gallon drums. This would minimize disposal costs, which are based on unit volume, rather than unit weight.

For Plant B, it was recommended that the mixing tank decontamination method be revised to include the use of a small pressure washer to apply carrier solution and a squeegee to clean the tank. The resulting spent solution should be collected for reuse in subsequent applications. This method would eliminate the generation of the pesticide-contaminated rags. In addition, this alternative also includes the placement of a shallow stainless steel pan underneath the mixing tank to catch any small spills which may occur during formulation or transfer operations. The pan should be slightly elevated and equipped with a spigot, so spills could be collected for reuse in pesticide formulation.

The pesticide-contaminated rags generated at Plant B are possibly classified as a hazardous waste, depending primarily on the quantity of pesticide in the rags. Sampling and analysis of the rags to determine the content of pesticide and carrier solvent in the rags would be required to determine if their content exceeds the hazardous waste criteria set forth in Article 11, Title 22, California Administrative Code. If the rags are determined to be a classified hazardous waste, they should not be disposed of in a sanitary landfill. An alternative method of handling and disposing of the rags as a hazardous waste is described in Appendix B which contains the Plant B Audit Report.

For Plant C, the following recommendations were developed:

1. Use mopping of floors in liquid pesticide formulating areas with dedicated mops and

squeegees to minimize the use of water hosing for floor washing. This practice will minimize the volume of floor wash water generated.

2. Install spray nozzles on all hoses to increase equipment rinsing efficiency thereby minimizing the volume of spent rinse water. This recommendation could include the use of wiper blades to physically wipe down the inside of the mixing tanks. The use of a water-knife type spray nozzle equipped with a high pressure booster pump could also be included as part of this recommendation.
3. Collect and reuse equipment rinse water for repetitive rinsing to minimize the volume of spent rinse water. This recommendation would involve the installation of rinse water holding tanks to facilitate its reuse, and possible two stage rinsing using more contaminated rinse water for the first stage of rinsing, and less contaminated rinse water for the final rinse.
4. Install flow meters on process water lines in each liquid pesticide formulating area to monitor water usage and the effects of various waste minimization techniques during trial implementation periods. Maintain a formal waste minimization program requiring operators to routinely record meter readings and waste quantities, and periodically review this data with management.
5. Use disposable coveralls, such as Tyvek suits, instead of cotton overalls for personnel engaged in formulating operations to minimize laundry wastewater.
6. Collect and analyze samples of boiler and cooling tower blowdowns to determine if these

waste streams are characteristic hazardous wastes. If nonhazardous, dispose of by discharge to one of the septic tank/drainfield systems.

7. Monitor stormwater runoff flow and quality to determine if it is a characteristic hazardous waste. Because of contaminant flushing during the initial stages of the wet season, the runoff may be classified as nonhazardous during the latter stages of the wet season. If so, the runoff should be handled as a nonhazardous liquid waste.
8. In the granule and dust mill flushing operation between batches, change from once through diluent flushing to repetitive flushing with a smaller volume of diluent. This recommendation may involve the installation of dedicated holding tanks for the used diluents, and could also include the use of two stage flushing. Furthermore, the establishment of a formal waste minimization program to periodically review waste generation by granule and dust mill operations should be considered.
9. Continue ongoing process wastewater treatability testing of activated carbon and expand as necessary to evaluate other applicable treatment technologies to not only evaluate reuse of the effluent in the plant, but also to support the discharge of the effluent to surface water or to a publicly-owned treatment works (POTW) should the sewer system be extended near the plant in the future.
10. Provide routine waste reduction training for operating employees.
11. Establish an incentive compensation system

whereby employees are rewarded for reducing waste generation, in proportion to the reduction in the company's waste management costs.

D.3.3 POTENTIAL ECONOMIC BENEFITS

As recommended in Chapter D.3.2 for Plant A, mechanical compaction of empty pesticide-contaminated paper bags and cartons in 55-gallon drums for disposal at a Class I landfill will very likely result in an appreciable reduction in disposal costs, which are based on volume rather than weight. At present, Plant A generates an annual average of five drums of waste containers per year which should be easily reduced to three or four drums per year with mechanical compaction.

A compaction device for use by a forklift could be manufactured for a cost of about $300. Plant A incurs a cost of $70 per drum for transportation and disposal at an approved hazardous waste disposal facility. Therefore, at an annual savings of $70, the period of return on the investment on the mechanical compaction device would be between 4 and 5 years.

For Plant B, the recommended alternative method for cleaning the mixing tank, as described in Chapter D.3.2, would require capital and additional operating costs of approximately $200 and $150 per year, respectively. The operating cost of $150 per year consists of an additional estimated 10 labor hours at $15 per hour required for rinsing the mixing tank with the pressure washer and collecting the spent rinse solvent for reuse in subsequent formulations. Due to the small quantity of pesticide-contaminated rags that is currently generated in decontaminating the mixing tank, the disposal cost for the rags is less than half of that for the recommended alternative method. However, as land disposal costs will undoubtedly increase, the alternative method will become increasingly more attractive.

Because the capital and operating costs for the existing and recommended waste management practices for Plant C are substantial, particularly relative to those for Plants A and B, the costs for implementing a recommended method were annualized for direct comparison with the annual costs for the existing waste management methods. The estimated implementation costs include the capital cost for any new equipment or facility improvements, as well as the operation and maintenance costs associated with the recommended technique. The capital cost was annualized using an interest rate of 10 percent and a 30 year period. The annual implementation cost is the sum of the annualized capital cost and the annual operation and maintenance costs.

Recommendations 1 through 4 for Plant C (Chapter D.3.2) were combined for the economic benefit assessment because they are all closely related and pertain to the reduction of equipment rinse water and floor wash water. The estimated implementation cost for these techniques is approximately $8,400 per year. The majority of this cost is for the installation, operation, and maintenance of spent rinse water collection systems to facilitate repeat use of the rinse water. Based on a unit disposal cost of $0.72/gallon, the implementation of these techniques would have to result in a wastewater reduction of almost 11,700 gallons per year to offset the implementation cost. This reduction represents approximately 60 percent of the current wastewater generation by equipment rinsing and floor washing operations. The success of these waste reduction techniques will mainly hinge on the effectiveness of repetitive use of the spent equipment rinse water. Consideration should be given to trial implementation of this technique on one of the pesticide formulating operations. The trial implementation would involve the installation of a temporary collection and storage system for the spent rinse water for subsequent reuse. It would also involve testing of repetitive use of the spent rinse water to determine the number of rinse cycles that could be used before the rinse water becomes too contaminated to allow effective rinsing. Consideration should also be given to two or three stage rinsing.

Recommendation 5 for Plant C (see Chapter D.3.2) involves the use of disposable coveralls, such as Tyvek suits, rather than cotton coveralls to minimize the volume of laundry wastewater. Because the disposable coveralls do not generally breathe as well as the cotton coveralls, they would likely be too uncomfortable during the warmer months of June through September. However, the use of disposable coveralls during the remaining months would minimize the volume of laundry wastewater. Assuming the use of 120 Tyveks per day for 165 days per year, the annual cost for the Tyveks would be approximately $47,000, and the disposal cost for the used Tyveks as a hazardous waste would be about $12,000 per year. In addition, the disposal cost for the laundry wastewater generated during the months of June through September based on a unit disposal cost of $0.72/gallon would be approximately $106,000. Therefore, the total cost of using disposable coveralls except during the four warmer months of the year would be about $165,000. At present, the annual disposal cost for the laundry wastewater is approximately $318,000, based on a unit disposal cost of $0.72/gallon. Consequently, the use of the disposable coveralls as described above would result in an annual savings of about $153,000. Although this recommendation appears to be very economically beneficial, Plant C should regularly evaluate the impact of the landfill ban program which could eventually prohibit landfill disposal of the contaminated Tyvek suits. In evaluating this recommendation, Plant C should also consider the waste classification of the Tyvek suits. Characterization of the contaminated Tyveks should be performed, as recommended for the pesticide-contaminated rags generated by Plant B, to determine the waste classification and appropriate waste disposal method.

Recommendation 6 for Plant C (see Chapter D.3.2) consists of the sampling and analysis of the boiler and cooling tower blowdowns to determine if these waste streams are characteristic hazardous wastes. At present, these waste streams combined amount to 24,000 gallons per year. They are disposed of as a hazardous waste at an annual cost of approximately $17,000. The collection and analysis of four samples of each of the two waste streams are recommended to provide a representative database for the hazardous waste determination. The estimated cost for collecting and analyzing eight samples for pesticides analysis is approximately $8,000. If these waste streams are found to be nonhazardous, then these waste streams could possibly be discharged to one of the existing septic tanks/drainfield systems. The installation of plumbing required for directing these waste streams to the septic tanks is estimated to be about $4,000, or an annualized cost of approximately $400 per year. Therefore, as nonhazardous wastes, these waste streams could be disposed of at a cost of about $400 per year, with a first year sampling and analysis cost of $8,000. These costs represent a savings of $8,600 during the first year of implementation, and an annual savings of over $16,000 per year thereafter.

Recommendation 7 involves monitoring of stormwater runoff flow and quality throughout the wet season. The purpose of this monitoring program is to determine if the runoff is nonhazardous, which may be the case particularly in the latter portion of the wet season. In order to develop a meaningful cost estimate for monitoring the stormwater runoff, an analysis of the drainage systems would be required. This analysis may indicate that numerous monitoring locations may be warranted to adequately investigate the potential contaminant source areas in the drainage systems. Even though the costs of such a monitoring program may be considerable, it is possible that it could be easily offset by the savings that may be realized in the event that some of the runoff is determined to be nonhazardous.

Recommendation 8 for Plant C consists of the use of repetitive diluent flushing of granule and dust mills rather than once through flushing. The repetitive flushing would be performed with a smaller volume of diluent than that used for the once through flushing to minimize the volume of spent diluent generated. A meaningful cost analysis of this recommended technique is not possible until a limited amount of trial implementation is performed. Trial implementation would involve the collection and repeated reuse of the diluent to determine the number of flushes that can be performed before the diluent becomes too contaminated to allow effective cleaning of the mill.

Recommendation 9 for Plant C involves continuing and possibly expanding the ongoing wastewater treatability studies. This recommendation is based on the significant economic benefit that could potentially be obtained considering the high cost of liquid waste disposal as a hazardous waste. At present, about $1.4 million is spent each year for the disposal of the process wastewater, including runoff, as a hazardous waste. Completion of the treatability and associated engineering feasibility studies will be required to perform a meaningful economic analysis of the various wastewater segregation/treatment/recycle options relative to the current wastewater disposal practice.

Recommendations 9 and 10 involve the provision of waste reduction training and incentive compensation programs for operating employees. The cost of these programs will depend on the level of training to be provided, and the type and magnitude of the incentive compensation system. Further evaluation of the employee training needs and overall compensation system at Plant C, as well as the anticipated waste management savings resulting from the implementation of these programs, is required to perform a meaningful cost/benefit analysis of this recommendation. Nevertheless, it is reasonable to assume that some long term benefit would be gained in the form of reduced waste management costs by implementing these types of employee programs.

APPENDIX E

SELF AUDIT FORMAT FOR PESTICIDE FORMULATING INDUSTRY

E-10.a

SELF AUDIT CHECKLIST

Company Name: ______________________ Name of Contact: ____________

Address: __________________________ Title/Position: _____________

Phone Number: ______________________ Phone Number: _______________

Annual Gross Sales:	Solvent-Based % Volume $	Water Based % Volume $	Solid Based % Volume $
Agricultural	___________	___________	___________
Industrial	___________	___________	___________
Household	___________	___________	___________

Annual Production Rates (gal or lbs)	1984	1985	1986	1987
Insecticides	____	____	____	____
Herbicides	____	____	____	____
Rodenticide	____	____	____	____
Fungicide	____	____	____	____
TOTAL				

EMPLOYEE DEVELOPMENT

Are employees trained on a regular basis to handle materials as hazardous wastes? ____ To reduce waste generation? ____

Are job functions defined for each employee? ____

Are employees given manuals that outline specific methods for handling the types of materials at your plant? ____

Are incentives offered to employees that encourage waste reduction? ____

Are good housekeeping procedures in place? ____

Are these procedures enforced with meaningful incentives or penalties? ____

Are good housekeeping procedures taught to all employees prior to beginning employment? ____

Do the housekeeping procedures stress waste minimization? ___

Are containers, cleaning tools, machinery, etc dedicated for specific materials or purposes? ____

Are your firm and its employees familiar with all Federal, State, and Local regulations that govern the pesticide industry and the wastes and products produced at your plant? ____

LABORATORY PRACTICES

Are laboratory tests conducted on a regular basis to quantify and qualify the types of hazardous materials present? ____

Are the laboratory quality assurance/quality control procedures performed on a regular basis? ____

Are wastes from the laboratory handled as all other wastes from the plant? ____

STORAGE

These questions apply to storage of raw materials and final products at your plant. Questions apply to bulk liquids as well as drums, containers, and packages.

Are all containers inspected by the quality control department before being accepted from the suppliers? ____

A complete inventory check is performed ____ times per year.

Is the inventory system computerized? ____

How is the usage of stored raw materials tracked?

- ____Stockroom attendant
- ____Access limited to designated personnel
- ____Sign-out sheet
- ____Materials are readily accessible to all personnel
- ____Other____

Are all materials stored to prevent damage to containers? ____

All stored materials monitored for leaks ____ times per week.

List all safeguards in place that prevent spillage of liquid and solid materials ____

____

____

When a spill or leak occurs, are there set procedures to follow? ____

Are key personnel notified and cleanup actions started immediately? ____

Are all personnel aware of the actions they are responsible for in the event of a leak or spill? ____

Are practice drills performed routinely in case of a major spill? ____

Are vapor recovery systems in place in the liquid storage facility to prevent the release of airborne contaminants? ____

Is dust generated in the storage area by the stored raw materials? ____

If so, is a dust recovery system in place in the solid material storage area? ____

Is dust generated from other sources in the storage area that could cause contamination of the stored materials? ____

Are materials stored in reuseable containers? ____

Are hazardous materials stored separately from nonhazardous materials? ____

Are materials stored in a high traffic area? ____

HANDLING

Is the layout of the plant such that the distance traveled with raw materials and end products is minimal? ____

What type of delivery system is in place for the transport of raw materials? ____

What delivery mechanism is used for the transport of final products? ____

Are spills and leaks monitored for during transport? ____

Does a cleanup procedure exist for possible spills and leaks during transport? ____

Is a plan in place that allows the waste generated from cleanups to be reused? ____

What types of response actions are implemented in case of spills and leaks during transport?

____Automatic shut off alarm

____Automatic flow cutoff

____Pipeline drainage

____Vapor/dust recovery

____Other____

Are employees aware of special handling procedures necessary for particular materials? ____

WASTE GENERATION

Check all waste generating activities that occur at your plant:

	VOLUME	SEGREGATED
____Wet Cleanups	_____	_____
____Dry Cleanups	_____	_____
____Equipment Cleaning	_____	_____
____Disposal of spent containers, bags,etc.	_____	_____
____Cleaning reusable containers	_____	_____
____Stormwater runoff	_____	_____
____Other______________________	_____	_____
________________________________	_____	_____

Are mass balances for the plant calculated on a regular basis?

____ If so, how often? ____per________

How often is cleaning of the process equipment performed?

____per________

Is the waste produced reused? ____

If not, how is the waste disposed of? ______________________

____

____

Is the solvent cleaning performed only on equipment used for solvent mixing? ____

Are the pipes used for transporting materials cleaned regularly? ____

Is the waste generated reused? ____

Is the waste generated kept segregated? _____

If not reused, how is the waste disposed of? ________________

____

____

______

Is the production of batches sequenced to reduce the necessity of frequent cleaning? ____

Is any of the equipment listed below used in the cleaning process?

Wiper blade _____
High pressure nozzle _____
Water wand _____
Spray knife _____

Are containers cleaned for the following uses?

Reuse _____
Resale _____
Disposal without cleaning _____

If they are reused, could they be dedicated thus reducing the need for cleaning? ____

If they are resold, could they be cleaned and reused? ____

If they are disposed of without cleaning, could cleaning take place and enable reuse or resale? ____

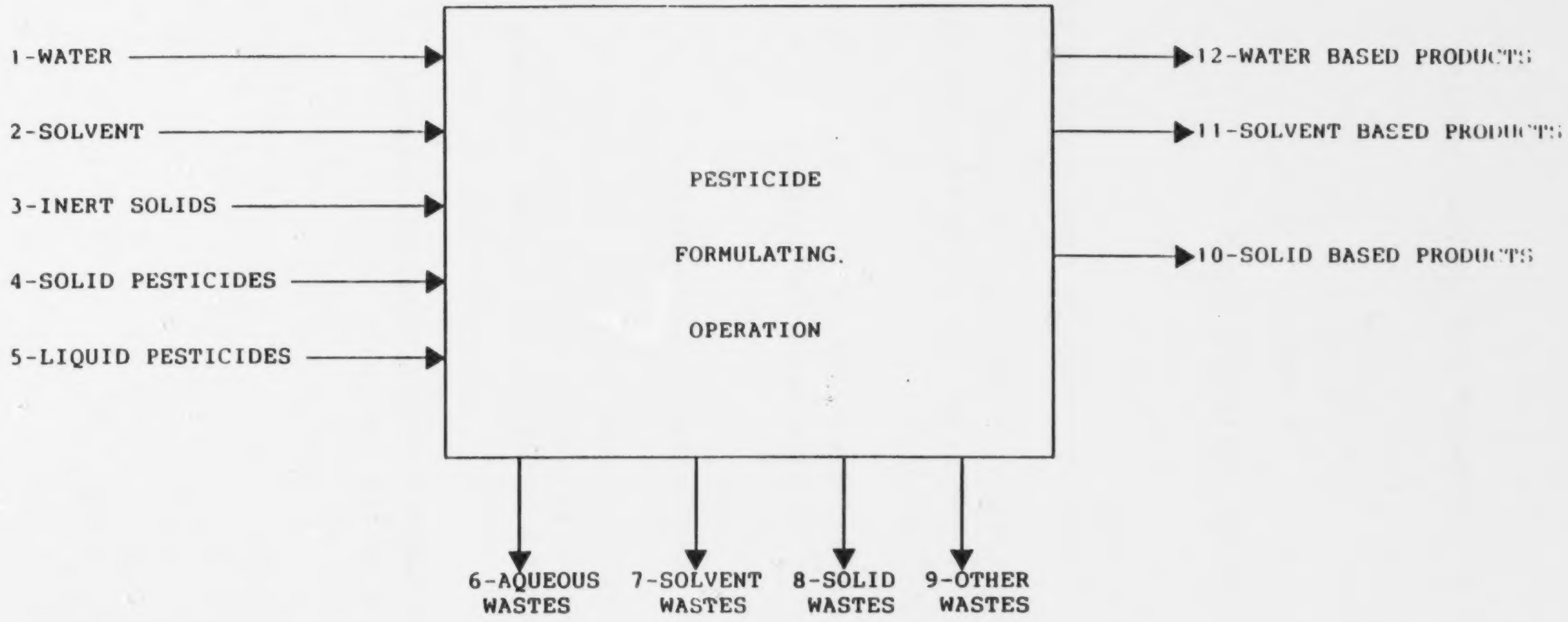
Are maintenance checks scheduled to coincide with regularly scheduled cleaning in order to eliminate unnecessary cleaning? ____

When blending solid based pesticides, is the dust recovered? ____

Is the dust recovery system designed to allow for reuse of the dust, either for cleaning or pesticide production? ____

When blending solvent based pesticides, is a vapor recovery system in use? ____

Provide a waste stream schematic with a material balance. Using the schematic, fill in the following table:


1-WATER
2-SOLVENT
3-INERT SOLIDS
4-SOLID PESTICIDES
5-LIQUID PESTICIDES
PESTICIDE
FORMULATING.
OPERATION
12-WATER BASED PRODUCTS
11-SOLVENT BASED PRODUCTS
10-SOLID BASED PRODUCTS
6-AQUEOUS WASTES
7-SOLVENT WASTES
8-SOLID WASTES
9-OTHER WASTES

	STREAM NUMBER											
	1	2	3	4	5	6	7	8	9	10	11	12
WATER, gal/yr												
SOLVENTS, gal/yr												
SOLIDS, lb/yr												
RAW PRODUCTS, lb/yr												
RAW PRODUCTS, gal/yr												

DISPOSAL

What disposal practices are currently in operation at your plant?

	COST
____Offsite hazardous waste landfill	____
____Offsite reclamation	____
____Waste exchange program	____
____Offsite sanitary landfill	____
____Treated onsite	________
____Onsite hazardous waste landfill	________
____Onsite sanitary landfill	________
____Other______________________________	________

How are wastes removed from your plant?

	COST
____Private waste hauler	________
____Recycler/reclaimer	________
____Public refuse system	________
____Other______________________________	________

Are wastes stored until a certain volume is reached, ____ or disposed of immediately ____?

SOURCE REDUCTION

Have any of the following been implemented to produce source reduction?

- ____Improve material handling, add controls
- ____Increase automation
- ____Computerized inventory control
    - ____raw materials
    - ____formulated products
    - ____wastes
- ____Employee training to minimize water usage
- ____Scheduling production and cleaning to minimize use of cleaning media
    - ____water
    - ____solvents
    - ____dust
    - ____granules
- ____Spill and leakage prevention measures
- ____Waste material tracking
- ____Process operation documentation
- ____Waste segregation
- ____Other ____

RECYCLING AND RESOURCE RECOVERY

Are wastewaters currently being treated for discharge? ____

If yes, specify ____

Could the treated wastewater be reused for any of the following?

____pesticide formulation
____container rinsing
____equipment cleaning
____floor washing
____other

Have individual process waste streams listed below been characterized by flow measurement and sampling and analysis? ____

____equipment rinse water
____floor wash water
____container rinse water
____stormwater runoff
____other aqueous waste amenable to treatment for reuse ____

Could individual waste streams or combinations of certain waste streams listed below be treated for reuse?

____equipment rinse water
____floor wash water
____container rinse water
____stormwater runoff
____other aqueous waste amenable to treatment ___________

Are used pesticide containers

____Returned to the pesticide supplier for refilling with the same pesticide
____Disposed of as hazardous waste without cleaning
____Triple rinsed and sold as scrap
____Triple rinsed and disposed of as a nonhazardous waste
____Triple rinsed and reconditioned onsite
____Triple rinsed and reconditioned offsite
____Shipped unrinsed to an offsite drum reconditioner

If triple rinsed, can the wastewater be reused? ____

TREATMENT ALTERNATIVES

Have bench-scale treatability tests been performed on wastes in an attempt to produce nonhazardous wastes? ____

Have bench-scale tests been performed on wastes in an attempt to reuse the treated water as process water? ____

Is your plant keeping up to date on the latest best available technologies for treatment of pesticide-related wastes? ____

If yes, what technologies show promise?

____activated carbon adsorption
____chemical oxidation
____resin adsorption
____steam/air stripping
____precipitation
____evaporation
____incineration
____biological treatment
____other ______________________

fold line

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Toxic Substances Control Division
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Document Title PESTICIDE FORMULATING INDUSTRY

1. Did you find information and procedures in this document to be helpful to your company?

_____very helpful _____helpful _____not helpful

2. Does the document accurately target the hazardous wastes in this industry?

_____yes _____no

If not, what has been overlooked?______________________________

3. Will information and procedures in this document help reduce waste management costs for your company?

_____yes _____no

If yes, please estimate costs or savings. $__________________

4. Are you aware of other legal waste management options for this industry which the document does not address?

_____yes _____no

If yes please describe______________________________

5. Please indicate your organization:

_____ Business targeted by Waste Audit

_____ Consultant

_____ Government (city, county, state, federal)

_____ other business/industry

_____ other (describe____________________________)

6. General comments or suggestions:______________________________

Thank you for your participation.

Please cut from the binder, then fold, staple, stamp, and mail.

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